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CORRECTIONS

Monthly Weather Review, February, 1930:

Page 45, Table 3, Davos, in September column, should be "385" instead of "585".

Page 53, second column, the first three paragraphs belong on page 58 just above the final paragraph in the second column.

Page 58, first column, the two last paragraphs should be inserted on page 53, at foot of first column.

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

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GREENLAND WEST-COAST FOEHNS: A DISCUSSION BASED ON THE FOEHNS OF JANUARY, 1929

By LEONARD R. SCHNEIDER

At the University of Michigan aerological station, Mount Evans, situated 75 miles east of Davis Strait, 30 miles west of the margin of the Greenland ice-cap, and 1,292 feet above sea level in latitude 66° 55′ N., and longitude 50° 50′ W., it is remarkable that one-fourth of the days of January, 1929, had hourly temperature averages above freezing. Also, during the same month along the west Greenland coast there was a new maximum temperature 10° higher than any January maximum temperature of the past 30 years.

In this paper these relatively high temperatures and periods of warm weather together with the other outstanding features associated with the three January foehns are set forth in the order in which the foehns occurred; also the exact nature and extent of the temperature, pressure, cloud, and wind changes occurring throughout the greater part of the month at one place in this west-coast region are shown by the graphs of the Mount Evans data. (Fig. 1.) But in this paper these weather summaries are included mainly because they serve as the fact basis for the chief consideration of this discussion, which is to show that the place of origin, manner of growth, and track of the LOW, are factors which largely determine the strength of the foehn. In this discussion, too, a new significance is attached to the Labrador northward moving secondary, a pressure development which has long been observed but never clearly analyzed.

Throughout the following pages Mount Evans data, Norwegian and Deutsche Seewarte synoptic charts and weather records kindly supplied by the Danish Meteorological Office have been the writer's chief references. Also at this place, the writer wishes to express his acknowledgments to Prof. H. U. Sverdrup and Dr. J. Bjerknes for their valuable counsel, and to Prof. W. H. Hobbs for permission to use the Mount Evans data.

We shall begin by pointing out the pressure distribution which was associated with the foehn of the 8th.

THE FOEHN—JANUARY 8, 1929

The pressure distribution during the first foehn was characterized by a remarkably high pressure to the east and south and a very low pressure to the west of Greenland. Let us consider each of these pressure developments for a moment. The beginning of the great high-pressure area may be said to have been on the 6th of January, when an already extensive European HIGH [1] joined the north Greenland anticyclone. The next important step occurred on the 7th when this newly combined HIGH joined a subtropic HIGH through the region 25° W. and 45° N., and when this occurred a great high-pressure ridge was set up, a ridge which extended across the North Atlantic from eastern and northern Greenland southward to the horse latitudes. This was the HIGH's maximum extent, but the development of the low-pressure area was perhaps more outstanding.

The LOW entered the United States over the State of Washington on the 2d of January and on the 5th we find it near Kansas City, Mo. However, it was after the LOW moved away from this plains region that it developed in a most singular manner. In fact, in the 24-hour movement from Kansas City the LOW not only became deeper by 0.52 inch, but it moved northeastward at an astonishing rate covering nearly 1,000 miles.[2] Following this, instead of continuing eastward and entering over the Atlantic Ocean we find that the above-mentioned vast Atlantic HIGH turned the LOW northward. At 10 p. m.[3] on the 7th, therefore, the LOW was centered near Cape Chidley as an exceptionally deep depression of the order of 27.91 inches. Twenty-four hours later, following a northeasterly course across Davis Strait, the LOW became occluded in the Jacobshavn-Upernivik district, but of concern here is that with the occlusion was the occurrence of the foehn, the features of which are as follows:

At Mount Evans, which was near the center of this LOW during its occlusion, anticyclonic weather preceded the foehn. Shortly before the foehn outbreak, however, which occurred about midnight of the 7th and which was marked by a temperature rise from 2° to 27°, three outstanding weather changes should be noted. In the order of their occurrence they were: (1) 6 a. m., beginning of the pressure decrease, (2) 10 a. m., gradually increasing sky cover of cirro-stratus from the south, and (3) 4 p. m., a beginning of slowly rising temperature. In the upper air, at least 12 hours before the outbreak, air was moving from off the ice-cap between the surface and 2,500 m. at a rather uniform velocity of approximately 7 m. p. s. (See fig. 4.) Above this, between 3,500 m. and at least to 5,000 m. and increasing with height from 11 to 27 m. p. s., air from the southwest was moving into the upper levels of the high-pressure region over the inland ice. It appears reasonably certain then, that air at the lowest levels at the ice margin was being impelled outward by the inflowing air aloft. At any rate, this air at the lowest levels could scarcely have come from the east coast of Greenland, at least at a corresponding level, for Scoresbysund on the 7th, had west wind and a temperature rise of 41.5°.

[1] The terms "High" and "anticyclone" are used synonymously.—Ed.

[2] M. W. R., Jan. 1929.—A. J. Henry—"Notes on January Weather."

[3] Time references are all according to 45th meridian time.

THE FOEHN—JANUARY 12–15, 1929

Down-slope winds of the 12th, 13th, and part of the 14th, which finally brought an extraordinary maximum of 50° to Mount Evans, must be attributed more to the increase in the pressure over the ice-cap region than to a decrease of pressure over Davis Strait. In fact, Angmagssalik, Scoresbysund, Upernivik, and Mount Evans had their highest pressures of the first half of the month at this time, and after the 10th readings lower than 29.33 inches did not occur in the immediate vicinity of Davis Strait until late on the 15th, when Cape Chidley reported 28.74 inches.

The singular beginning again of the foehn on the 15th, after an approximate 24-hour interruption in which there was an outbreak of cold air from the north, was apparently due to the increased pressure gradient brought about by a newly-formed and deeper depression lying centered over northern Hudson Bay. On the 16th temperature and pressure had already begun to decrease, but on this day four quick pressure decreases followed by equal increases were outstanding. These fluctuations are, no doubt, to be ascribed to outrushes of air taking place when the depression was near enough to release some of the ice-cap air.

Upper-air conditions on the 11th, as on the day preceding the 8th, showed air from the southwest at high levels at approximately 5,000 meters. Whether this current increased or decreased after the 11th can not be stated because clouds in the neighborhood of 2,500 meters cut short the pilot-balloon flights. Below the cloud level wind prevailed from off the ice cap during the days of the foehn.

THE FOEHN—JANUARY 21–25, 1929

The third foehn was the most outstanding; Mount Evans had a high maximum of 51.8° and 102 consecutive hours averaging 10° above freezing, and Godthaab and Jacobshavn had maximums of 61.3° and 59.1°, respectively 9.9° and 10° greater than their next highest January maximums at least since 1900.[4] In addition to these temperatures there were three features which were outstanding at Mount Evans. They were: (1) Fluctuating pressure on and about the 23d; (2) wind of great velocity occurring on the first five hours of the 24th, the hourly velocities in miles per hour being 56, 80, 73, 70, and 52; and (3) the high pressure following the temperature decrease and the end of the foehn. It is interesting to note that these exceptional conditions occurred under pressure conditions which were also peculiar.

The LOW contributing to the development of this foehn may again be traced to the plains region of the United States, and in the 24-hour movement from that region it proceeded in a manner even more unusual than the LOW of the 8th, for after the morning of the 18th, while the LOW became deeper by only 0.36 inch, it moved northeastward an amazing distance, approximately 1,500 miles.[5] Compared with the earlier depression, the distance was farther and the deepening not so great, but in a later stage east of Labrador the pressure (27.75 inches at 10 p. m. January 21) was 0.16 inch lower than the Cape Chidley LOW. High pressure over the eastern North Atlantic Ocean was again, no doubt, a chief factor in stopping the LOW immediately east of Labrador, but increase in pressure along the east and west coast and therefore presumably over Greenland, roughly estimated at a minimum 0.50 inch greater than on the foehn of the 8th, probably partly accounts for the greater development of the foehn of the 21st.

However, too great significance should not be given this increase in pressure, for it may also have tended to decrease the strength of the foehn by reducing the pressure gradient between the coastal region and that over the ice cap. Thus the strength of the foehn becomes not so much a matter of the depth of the pressure along the coast (for as such the first foehn should have reached the highest temperatures), but it is as will be explained, instead, a matter which reverts to the origin and course of the LOW.

In the case of the last foehn it will be repeated that the center of the LOW followed a southerly course and moved eastward over the St. Lawrence track, but a significant fact is that it was extremely deep and that it became a great stationary cyclone east of Labrador. Since this depression remained fairly deep over four or five days and since there is not definite proof that the original LOW moved northward, then the pressure and temperature changes which occurred along the Greenland coast during these days must be attributed to secondaries of this stationary depression. With this being true, if their origin and growth are explained, then certain comparisons can be made between Labrador secondaries and those LOWS which come directly to the Greenland coast after having first crossed North America. The second foehn without any well-formed LOW moving toward Greenland from North America also came about while the Labrador LOW was especially well marked, so the matter of secondaries might again be considered, but since the secondaries of the second and third foehns show so much in common, only one discussion of this type is necessary. Concerning the first foehn and its LOW of a different character, however, all comparisons and explanations will come after the following discussion which considers how secondaries may form on the north or cold side of a stationary Labrador cyclone.

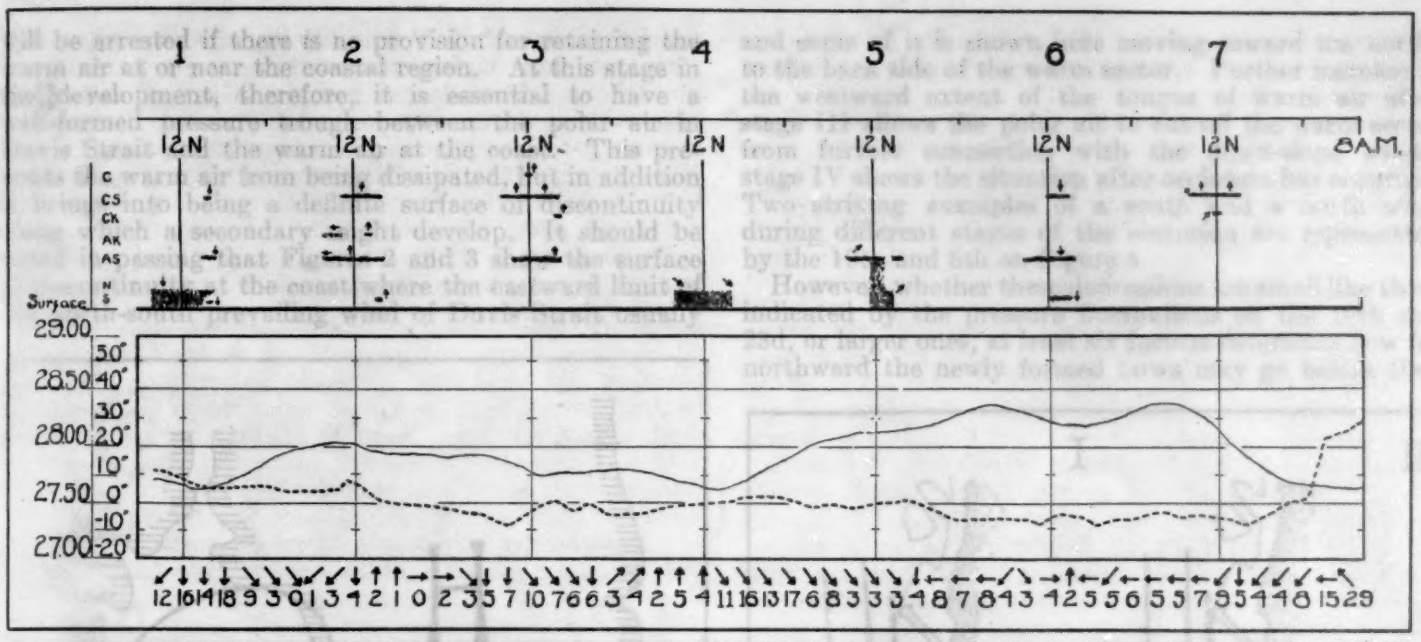
Two contiguous masses of air of unlike temperature moving in opposite directions, or with different velocities in the same direction, are sufficient cause for the formation of a cyclonic depression.[6] Near the Greenland coastal fringe either of these ways may be operative in forming a secondary, but in any case it is the movement of air from off the ice cap which seems to be all important. In other words, it is to be understood that the ice cap as a great topographic feature is of such height, character, and extent that it becomes a dominant control in at least one part of the weather of the Arctic. In a situation like that of the 21st, for example, as is shown in Figure 2, the part played by the ice cap in building the secondary is clearly evident.

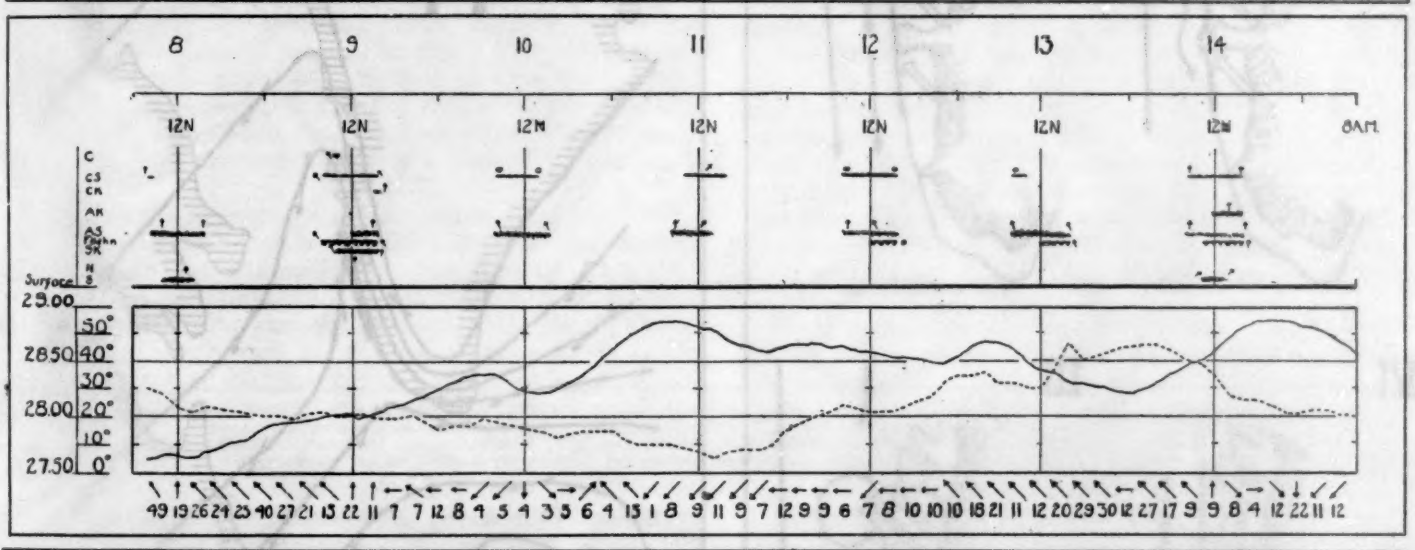
As is shown on the figure, a great amount of air moving around the north of the Labrador LOW is deflected around the Cape Farewell region. With this deflection comes an increase in velocity which probably carries much of the air over the southernmost part of the ice mass. Therefore, when it descends from this elevation the air will be warmed adiabatically and a temperature difference between this air and that in Davis Strait will begin. This is the step which is so important at the beginning, for by reason of this increase in temperature and consequent decrease in pressure an increasingly larger amount of air from over the ice cap will descend and be pushed onto the coastal region, will increase the extent and temperature of the warm air there. But all further increases

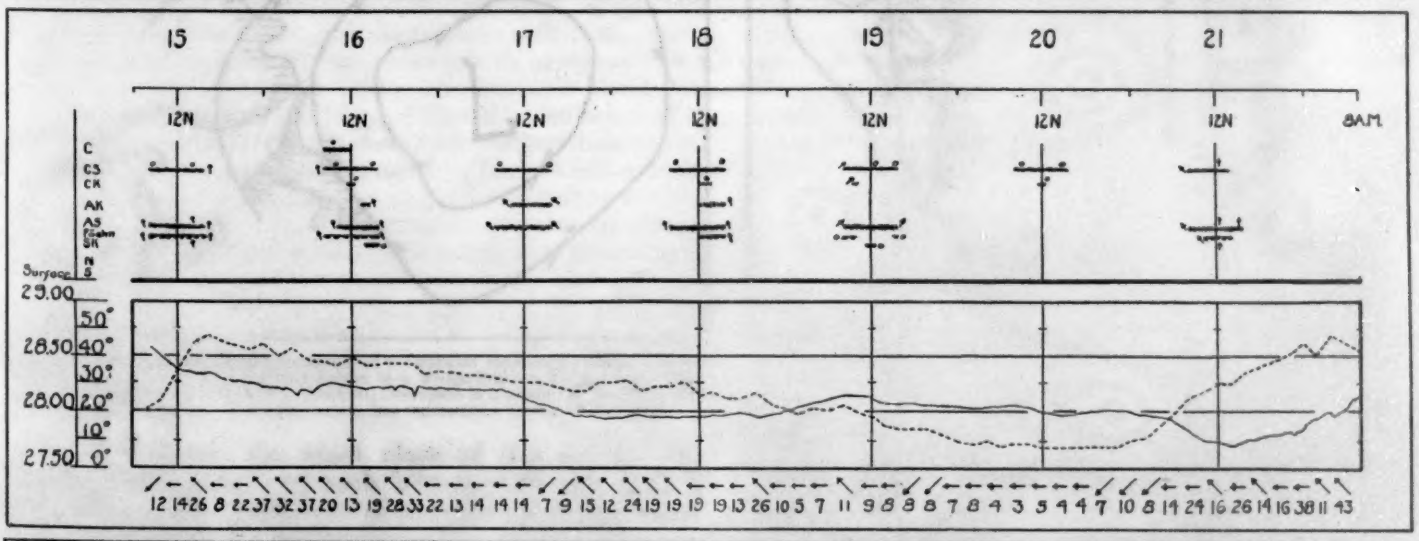
[4] Data not available for Jacobshavn for the years 1912 and 1918; for Upernivik in 1913, 1914, and 1927.

[5] MONTHLY WEATHER REVIEW, ibid.

[6] According to the Bergen School.







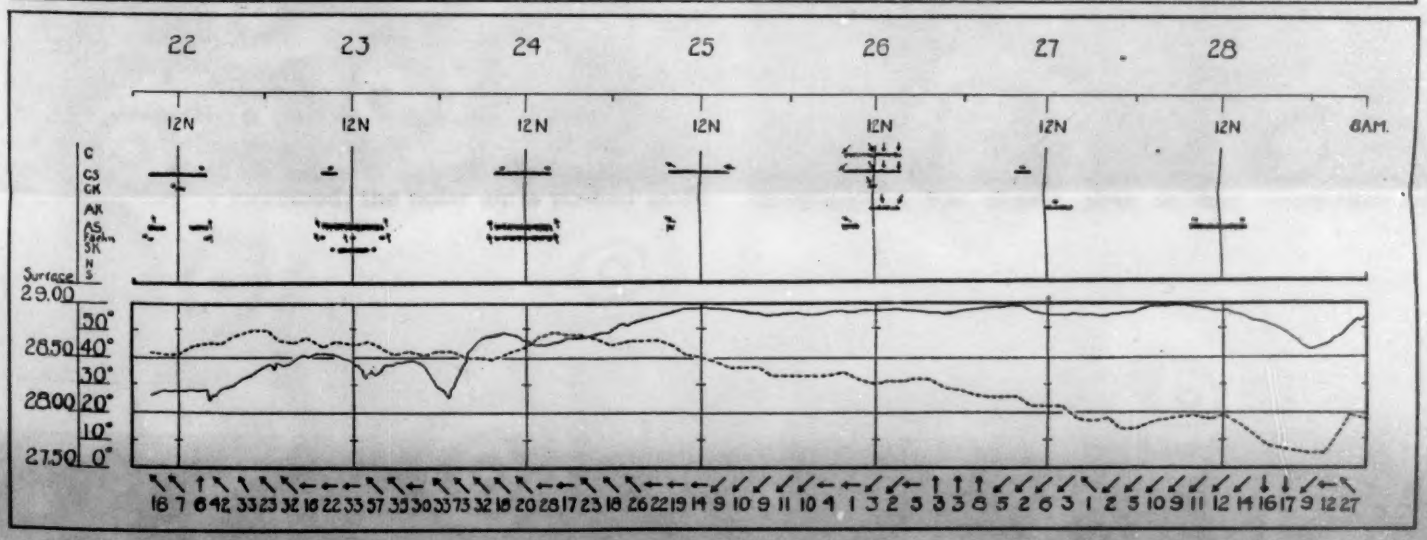


FIGURE 1.—Graphic representation of meteorological data of Mount Evans from Jan. 1 to 28, 1929. Numbers across the top refer to days; "12 N" is 12 o'clock noon. Cloud heights are represented as being alike on all days. Direction of cloud movement is shown by arrows which fly with the wind; the top of the graph is north, the right side, east and so on. The broken line represents the temperatures of every second-hour; the solid line is a reproduction of the barograph trace (add 1.39 for sea-level values). Wind direction and velocity in miles per hour is for every third hour

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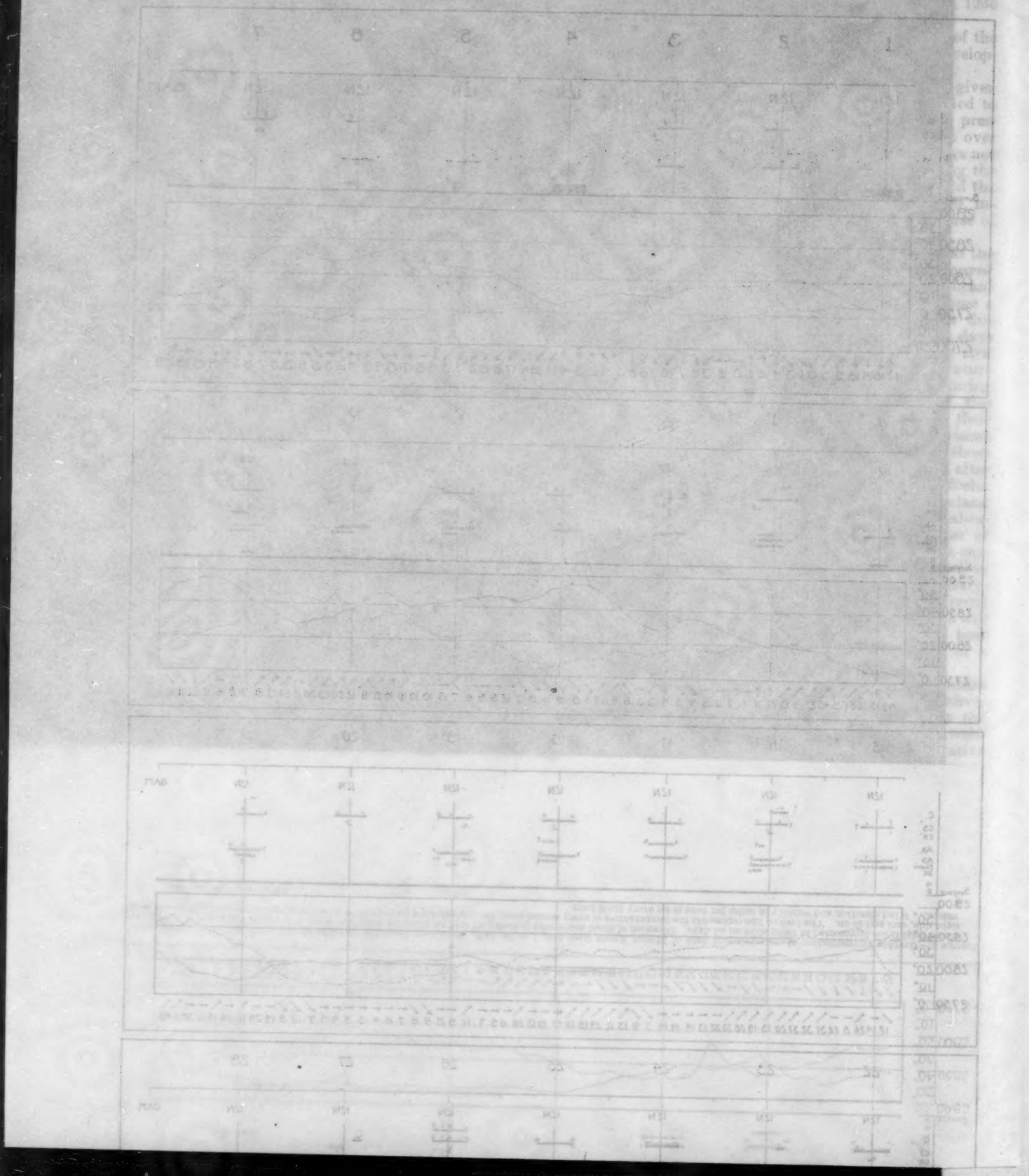

will be arrested if there is no provision for retaining the warm air at or near the coastal region. At this stage in the development, therefore, it is essential to have a well-formed pressure trough between the polar air in Davis Strait and the warm air at the coast. This prevents the warm air from being dissipated, but in addition it brings into being a definite surface of discontinuity along which a secondary might develop. It should be noted in passing that Figures 2 and 3 show the surface of discontinuity at the coast where the eastward limit of the north-south prevailing wind of Davis Strait usually

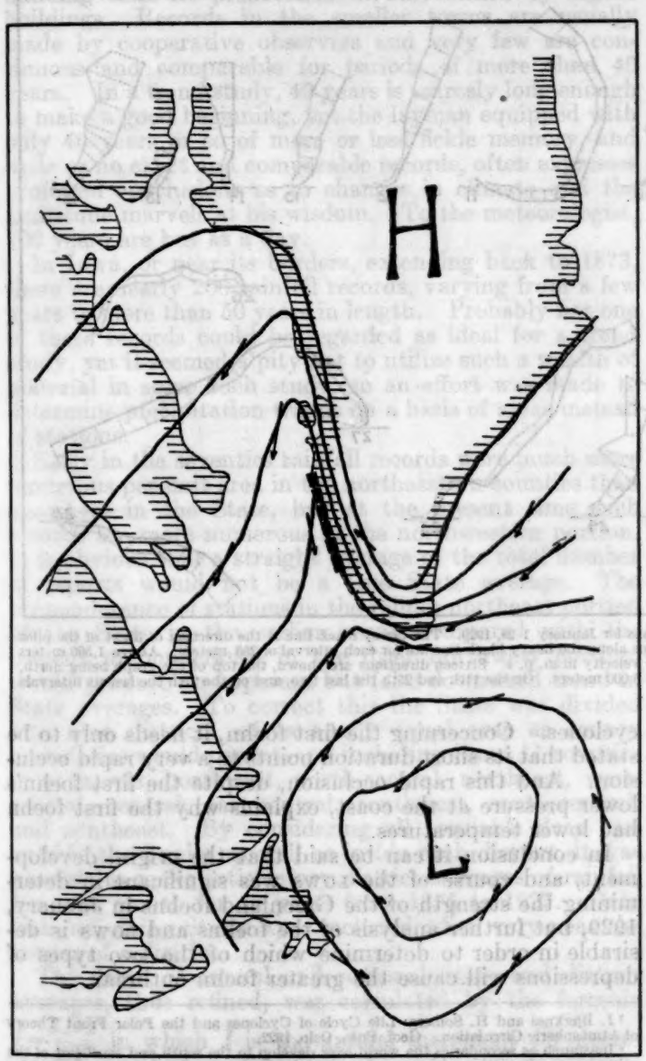

FIGURE 2.—The first step in the formation of a Labrador secondary. Note how the Greenland anticyclone and ice mass extend as a wedge into the Labrador LOW and how the increased wind velocity at southern Greenland is explained by the crowding of isobars in that region. The wide broken line represents a line of discontinuity

occurs. However, the exact place of this surface will largely be determined by such factors as the strength of the foehn or the conditions of pressure or temperature of the polar air in Davis Strait.

With a discontinuity surface definitely formed, the development of the secondary may occur anywhere along its extent. For example, Figure 3, Part I, shows how the outpouring from off the grand slope of the ice cap may provide a large amount of warm air to any wave which might form; in Parts II and III the amplitude of the warm wave is increased, the polar air is pushed aside and some of it is shown here moving toward the north, to the back side of the warm sector. Further increase in the westward extent of the tongue of warm air after stage III allows the polar air to cut off the warm sector from further connection with the down-slope winds; stage IV shows the situation after occlusion has occurred. Two striking examples of a south and a north wind during different stages of the occlusion are represented by the 19th and 6th on Figure 4.

However, whether these depressions are small like those indicated by the pressure fluctuations on the 16th and 23d, or larger ones, at least six factors determine how far northward the newly formed LOWS may go before they

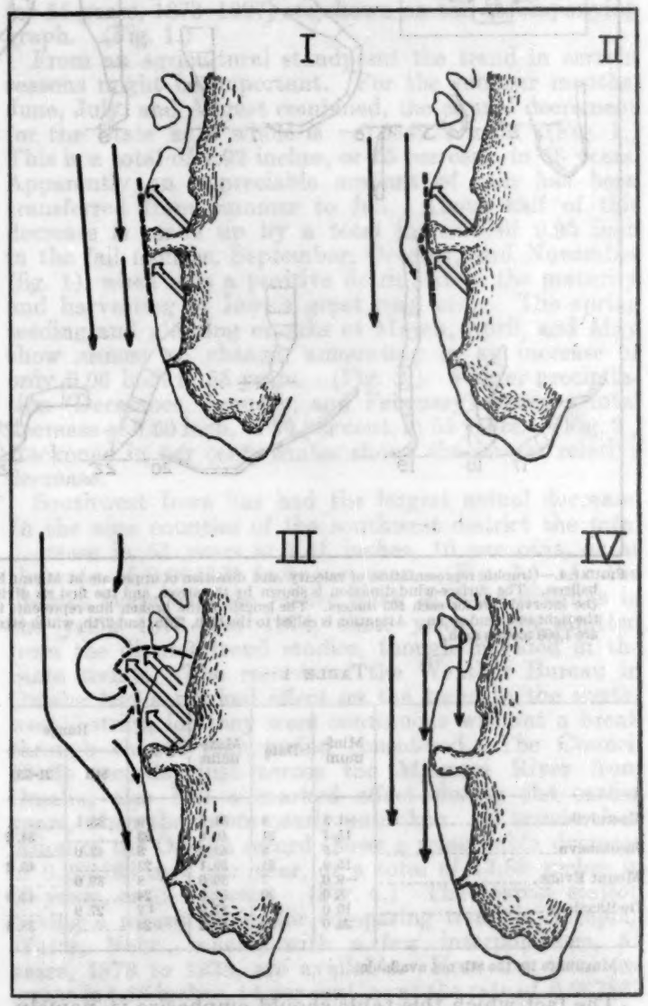

FIGURE 3.—A continuance of the situation begun in Figure 2

are occluded. Listed somewhat according to significance, consideration must always be given to the first five of the following: (1) The energy received at the beginning; (2) the temperature contrast developed by the foehn; (3) the amount of pressure gradient northward; (4) the direction of air movement in Davis Strait, i. e., whether speeded by southerly or retarded by northerly currents; (5) the energy gained from latent heat; and (6) the effect of the pocketlike configuration of Melville Bay. That only northward movement of these secondaries has been considered may be simply explained by the presence of SE. and SSE. winds in the warm sector, for investigation has shown that in any depression the

direction of movement is [7] in the direction of the warm sector current, i. e., approximately parallel to the isobars of the warm sector.

The temperatures and therefore the strength of the foehns resulting from LOWS having very different histories is shown by Table 1. In other words, the LOW of the 8th which moved along a northerly track directly from the plains region of the United States to the Greenland coast is to be compared with the secondary developments which have just been described in some detail.

ondary, or secondaries,[8] not only began with higher temperatures, but higher temperatures were maintained throughout a much longer period. Many of the conditions relating to the last foehn have already been given in some detail, so it is only necessary to state here, that of greatest importance in determining the strength of this foehn was the fact that the Labrador depression was extremely deep. Without this, the secondaries would never have begun with such great energy, nor could they have shown so many characteristics peculiar to young

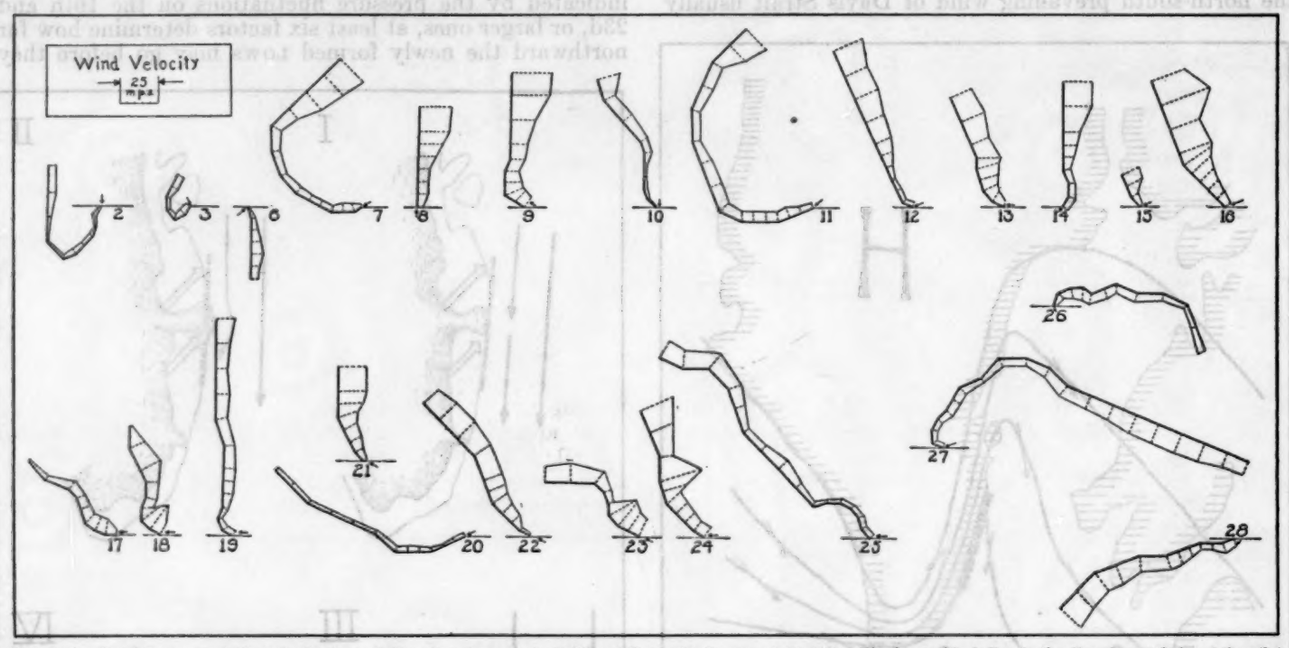

FIGURE 4.—Graphic representation of velocity and direction of upper air at Mount Evans for January 1–28, 1929. The heavy black line is the direction of flight of the pilot balloon. The surface-wind direction is shown by the arrow, and the first six divisions along the heavy black line are for each interval of 250 meters. Above 1,500 meters the intervals are for each 500 meters. The length of the broken line represents the velocity in m. p. s Sixteen directions are shown, the top of the graph being north, the right east, and so on. Attention is called to the 11th, 25th, and 27th, which exceed 5,000 meters. On the 11th and 25th the last two, and on the 27th the last six intervals are 1,000 meters each.

TABLE 1

	Minimum	Date	Maximum	Date	Range 8th	Range 21–25
Upernivik	−1.3	8	31.8	9	33.1	
	15.4	21	49.6	23		34.2
Jacobshavn	.5	8	43.5	8	43.0	
	15.9	21	59.1	23		43.2
Mount Evans	−9.0	7	30.0	8	39.0	
	8.0	20	51.8	24		43.8
Godthaab	10.0	7	37.9	[1] 7	27.9	
	23.0	21	61.3	24		38.3

[1] Maximum for the 8th not available.

The fact which this table should emphasize is, namely, that of the two foehns, the last one produced by a secondary cyclones. Concerning the first foehn, it needs only to be stated that its short duration points to a very rapid occlusion. And this rapid occlusion, despite the first foehn's lower pressure at the coast, explains why the first foehn had lower temperatures.

In conclusion it can be said that the origin, development, and course of the LOWS was significant in determining the strength of the Greenland foehns in January, 1929, but further analysis of the foehns and LOWS is desirable in order to determine which of the two types of depressions will cause the greater foehn outbreak.

[7] J. Bjerknes and H. Solberg: Life Cycle of Cyclones and the Polar Front Theory of Atmospheric Circulation. Geof. Pub., Oslo, 1922.

[8] Inasmuch as secondaries the world over develop to the south and southeast of the primary, an alternative view may be entertained, viz, that for the reasons stated by the author there was a redevelopment of energy along the Greenland coast in the original primary cyclone rather than the development of a secondary cyclone.—*Ed.*

SECULAR TREND OF IOWA PRECIPITATION

By CHARLES G. REED

[Weather Bureau, Des Moines, Iowa]

Before entering upon such a study as this, careful consideration must be given to the source and comparability of the data. One is always anxious to use a continuous record that extends back as far as possible. City rainfall records must be used with care, for they have usually been obtained in two or more locations, each on a higher building than its predecessor or surrounded by higher buildings. Records in the smaller towns are usually made by cooperative observers and very few are continuous and comparable for periods of more than 40 years. In a trend study, 40 years is scarcely long enough to make a good beginning, yet the layman equipped with only 40 years or so of more or less fickle memory, and little or no exact and comparable records, often expresses profound conclusions as to changes in climate and the multitude marvels at his wisdom. To the meteorologist, 100 years are but as a day.

In Iowa, or near its borders, extending back to 1873, there are nearly 200 rainfall records, varying from a few years to more than 50 years in length. Probably not one of these records could be regarded as ideal for a trend study, yet it seemed a pity not to utilize such a wealth of material in some such study, so an effort was made to determine precipitation trends on a basis of areas instead of stations.

Early in the seventies rainfall records were much more numerous per unit area in the northeastern counties than elsewhere in the State, but at the present time such records are more numerous in the northwestern portion. It is obvious that a straight average of the total number of reports would not be a true State average. The preponderance of stations in the rainier northeast portion of the State in the earlier years, compared with the present preponderance in the drier northwest portion, would produce an apparent but false downward trend in State averages. To correct this the State was divided into nine districts, of as nearly equal area as county boundaries would permit, and including about 11 counties in each, viz, northwest, north-central, northeast, west-central, central, east-central, southwest, south-central, and southeast. By considering all available data just outside the border as well as inside each district, it was possible to make satisfactory district averages of rainfall for each month for 53 years from 1875 to 1927. Data from adjoining States were included when very near the border of a district.

The trend of annual and seasonal State and district averages, thus refined, was calculated by the formula $I=\frac{\Sigma DY}{\Sigma Y^2}$ in which I is the annual increment (or decrement), D is the average rainfall of each year, and Y the number of each year, starting from the middle year, numbering up and down and prefixing a minus sign to all years before the middle year. The mean rainfall of the series is entered opposite the middle year and the annual increment or decrement added successively each way till the first and last years of the series are reached. The totals of precipitation at the end of each year represent points in a series of events, so the number of intervals between points is one less than the number of years. To cover the full period it is necessary to project the trend line backward through the first year of the series; so in practice, the annual increment, I, is multiplied by one more than the number of years preceding the middle year and the product added (algebraically, since I may be either positive or negative), to the mean of the whole series to get the value of the beginning of the trend line, on January 1 of the first year. With simple events, each of which does not represent an appreciable period of time, this amplification is not necessary.

For the 12 calendar months the annual decrease in rainfall for the State as a whole is -0.036354 inch, or 2 inches in 55 years. The annual averages and trend line for 55 years, 1873–1927, are shown on the accompanying graph. (Fig. 1.)

From an agricultural standpoint the trend in certain seasons might be important. For the summer months, June, July, and August combined, the annual decrement for the State as a whole is -0.034925 inch. (Fig. 1.) This is a total of 1.92 inches, or 15 per cent, in 55 years. Apparently an appreciable amount of rain has been transferred from summer to fall. About half of this decrease is made up by a total increase of 0.95 inch in the fall months, September, October, and November (fig. 1), when it is a positive detriment to the maturity and harvesting of Iowa's great corn crop. The spring seeding and planting months of March, April, and May show almost no change, amounting to an increase of only 0.06 inch in 55 years. (Fig. 2.) Winter precipitation (December, January, and February) shows a total decrease of 0.90 inch, or 39 per cent, in 55 years. (Fig. 2.) Reckoned in per cent, winter shows the largest relative decrease.

Southwest Iowa has had the largest actual decrease. In the nine counties of the southwest district the total decrease in 53 years is 3.41 inches, 10 per cent, or at the rate of 0.064321 inch per year. (Fig. 3.) As the district averages were rather weak in some districts in the years 1873 and 1874, these years were omitted from the district trend studies, though included in the State trends. The records of the Weather Bureau in Omaha had a marked effect on the trend in the southwest district, for they were continuous without a break through the 53-year period considered. The Council Bluffs records, just across the Missouri River from Omaha, also had a marked effect during the earlier years, when they were nearly unbroken. A trend calculation of the Omaha record shows a remarkable decrease of 0.262168 inch per year, or a total of 13.89 inches in 53 years, or 39 per cent. (Fig. 4.) The nearest station having a record useful for comparing trend is Weeping Water, Nebr., where, with a few interpolations, 51 years, 1878 to 1928, are available. Here the total decrease is 4.48 inches, 14 per cent, or at the rate of 0.087867 inch per year. For the State of Nebraska as a whole, in the 53 years, 1876–1928, the total decrease is 1.56 inches, 6 per cent, or 0.029439 inch per year.

The only station actually in the southwest district having a record warranting a trend calculation is Clarinda. Including interpolations recently made for use in the forthcoming revision of Hann's Climatology, for the years 1878 to 1887, inclusive, it is possible to make a 53-year trend, 1876–1928, inclusive, which shows an annual *increase* of 0.035030 inch, or a total *increase* of 1.86 inches, or 5.8 per cent, instead of a decrease.

Either there must be an area centering about Omaha where there is an abnormal long-time downward trend or else some sort of unfavorable conditions not readily

apparent are developing and progressing in connection with the exposure of the rain gage. The rainfalls of the eighties were very heavy at Omaha, which gives the trend line a steep downward slope.

The averages for the west-central district were but slightly influenced by the Omaha records, yet the total decrease in that district in 53 years is 2.35 inches, 7 per cent, or about 0.044318 inch per year. Next stand the east-central and northeast districts, each with a

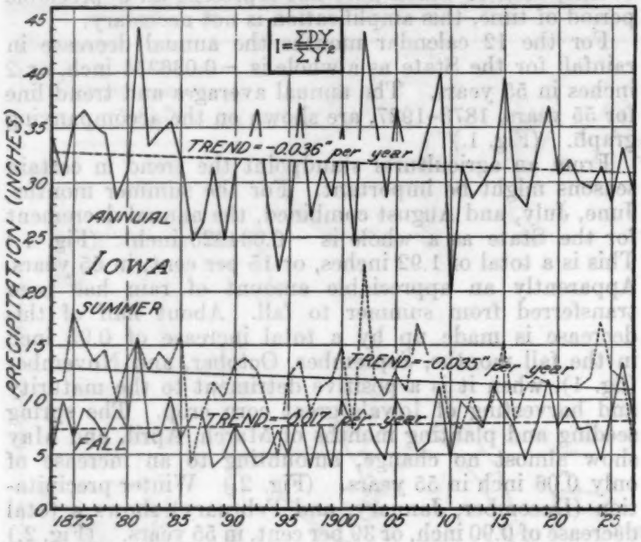

FIGURE 1.—Annual precipitation in Iowa has decreased at the rate of 0.036 inch per year for 55 years. Summer rainfall has noticeably decreased or been partly transferred over into the fall months

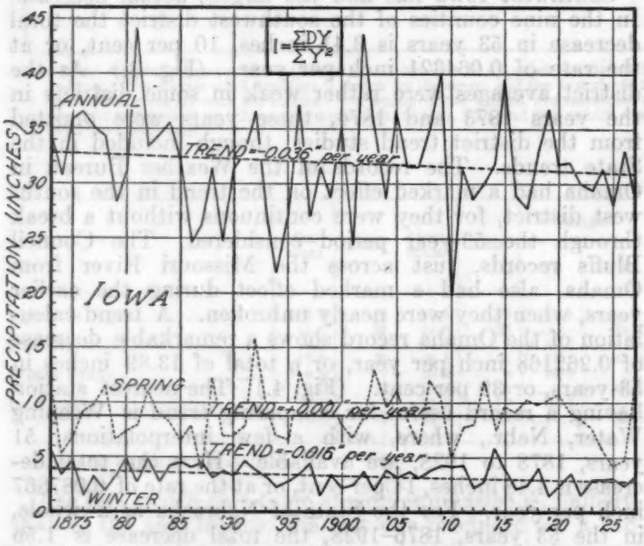

FIGURE 2.—Spring precipitation in Iowa has not changed appreciably in 55 years, but winter precipitation has decreased 39 per cent

decrease of 2.29 inches. At Independence, Buchanan County, in the northeast district, the total decrease in rainfall is 4.66 inches, or 14 per cent, in 59 years, 1869–1927. This is at the rate of 0.07915 inch per year. At Dubuque, Dubuque County, also in the northeast district, the total decrease is 4.89 inches, or 14 per cent, in 77 years. This is at the rate of about 0.063550 inch per year. The least decrease is in the northwest district, where it amounts to only 0.20 inch. Algona, Kossuth County, near the middle of the northern boundary of the State, shows not a decrease but a total increase of 0.21 inch in 55 years, in spite of the claim that drainage of northern Iowa land has reduced the rainfall. In fact, this study shows the greatest decrease in rainfall is in the southwest district where there has been the least drainage of land. State-wide records in Minnesota are not of sufficient length to be comparable with Iowa data, but the total increase in rainfall at Fort Snelling and St. Paul is 1.19 inches in 91 years, 1837–1927, and

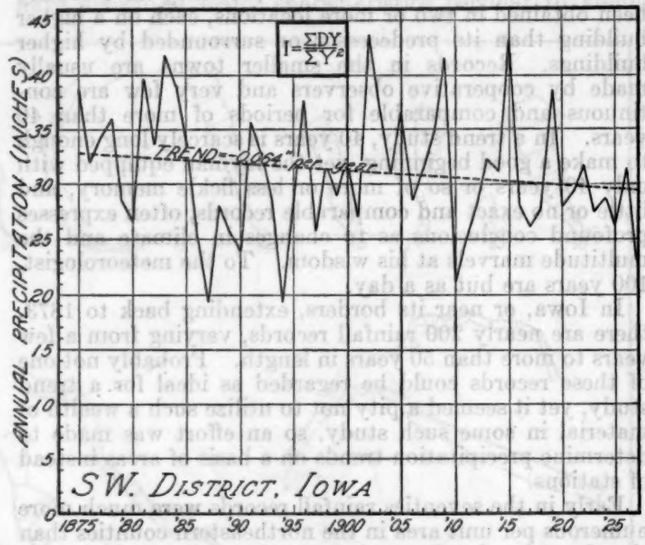

FIGURE 3.—The greatest decrease in Iowa precipitation is in the southwest district where it amounts to 3.41 inches in 53 years

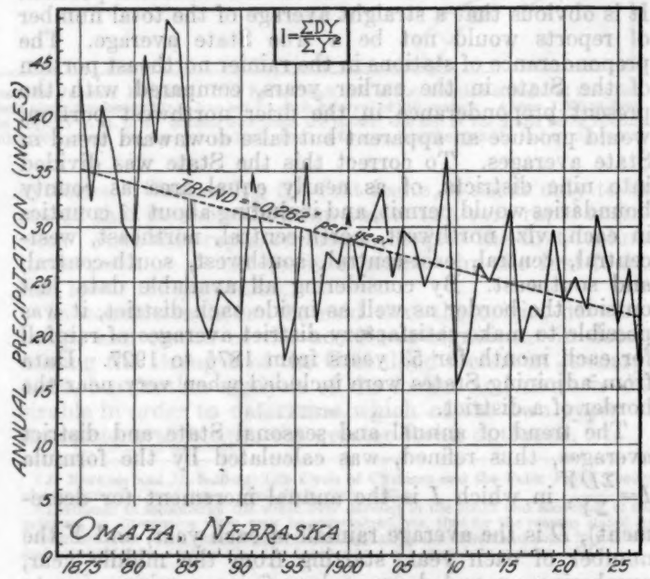

FIGURE 4.—The greatest decrease in the region is centered at Omaha where it amounts to 13.89 inches or 39 per cent in 53 years

it seems probable that the general trend of Minnesota rainfall is upward. The distribution of the total decrease in precipitation in 53 years by districts in Iowa is shown on the accompanying map. (Fig. 5.)

The trend by districts for the three principal crop months, June, July, and August combined, is shown on the accompanying map. (Fig. 6.) Here again the largest decrease is in the southwest district, where it is 3.34 inches, or 23 per cent, and almost the same as for

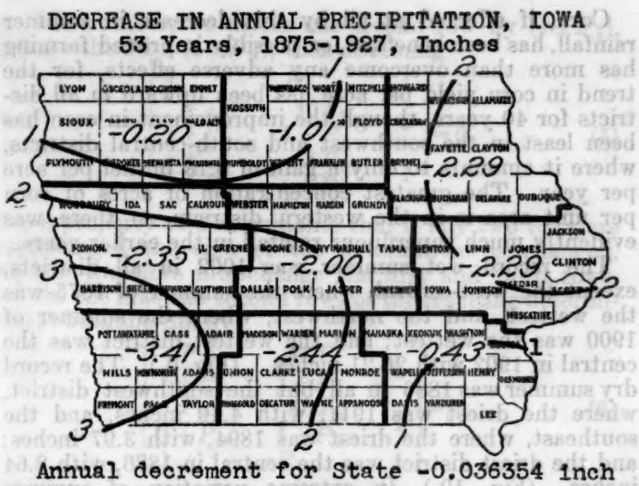

FIGURE 5.—Iowa precipitation has decreased markedly from southwest to northeast but very slightly in the northwest district

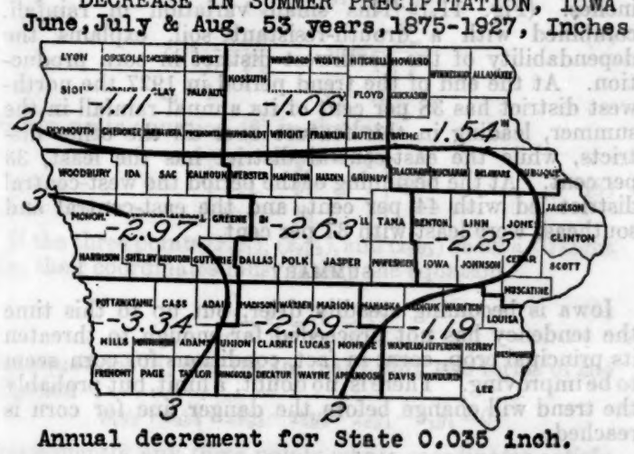

FIGURE 6.—Summer precipitation in Iowa has decreased decidedly in the southwest and west-central districts, around which the decrease diminishes in regular zones

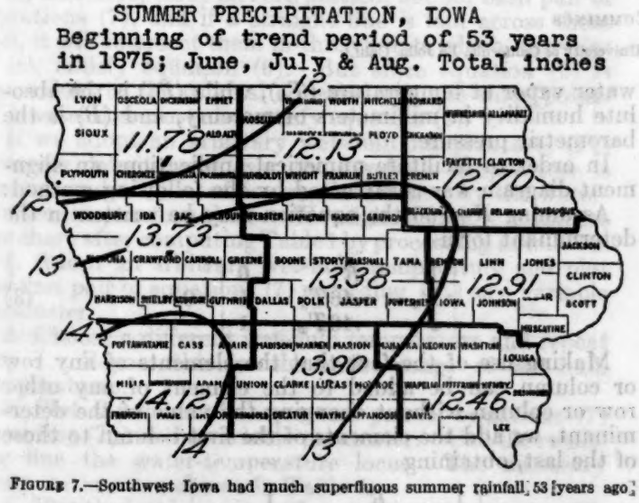

FIGURE 7.—Southwest Iowa had much superfluous summer rainfall 53 [years ago]

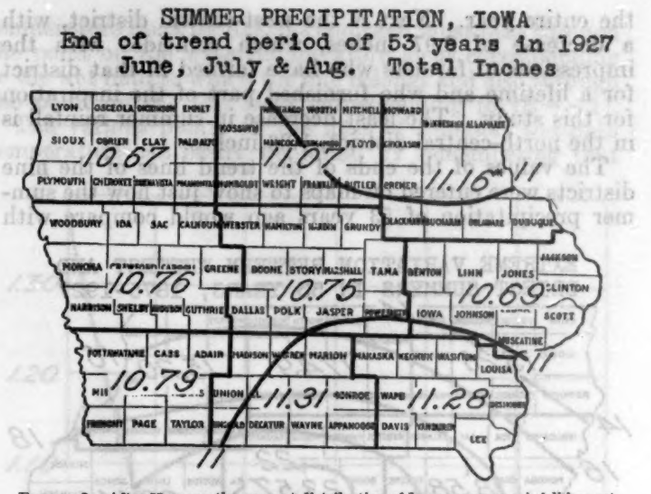

FIGURE 8.—After 53 years, the present distribution of Iowa summer rainfall has settled down to what appears to be a normal, stable, distribution over the State

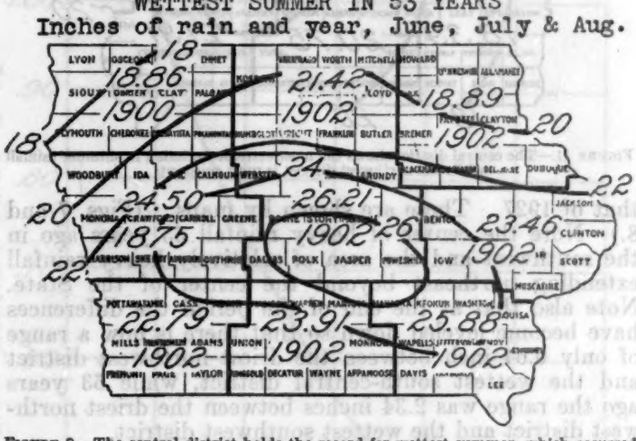

FIGURE 9.—The central district holds the record for wettest summer, which occurred in 1902

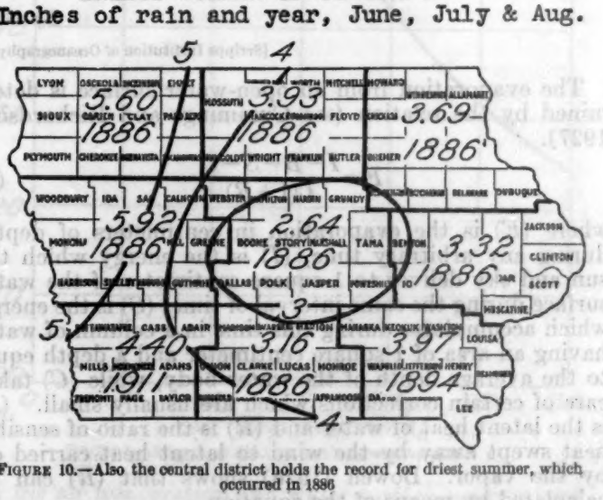

FIGURE 10.—Also the central district holds the record for driest summer, which occurred in 1886

the entire year. Next is the west-central district, with a decrease of 2.97 inches, which coincides with the impressions of farmers who have farmed in that district for a lifetime and who furnished part of the inspiration for this study. The least decrease in summer rainfall is in the north-central district, 1.06 inches.

The values of the ends of the trend lines of the nine districts were entered on maps to show just how the summer precipitation of 53 years ago would compare with

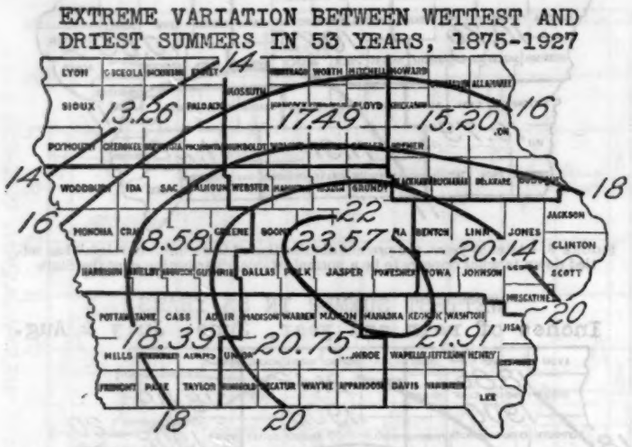

FIGURE 11.—The central district shows the most extreme variation in summer rainfall while the northwest district is most constant

that of 1927. These are shown by maps. (Figs. 7 and 8.) Note the center of heavy rainfall 53 years ago in the southwest and the area of relatively heavy rainfall extending northeast beyond the center of the State. Note also that at the end of the period the differences have become leveled down so that there is now a range of only 0.64 inch between the driest northwest district and the wettest south-central district, while 53 years ago the range was 2.34 inches between the driest northwest district and the wettest southwest district.

Corn, if affected at all by this decrease in summer rainfall, has been benefited, or possibly improved farming has more than overcome any adverse effects, for the trend in corn yield per acre has been upward in all districts for 40 years, though the improvement in corn has been least in the southwest and south-central districts, where it amounts to only a gain of 0.18 bushel per acre per year. The greatest concentration of acres of corn per unit area is in the western districts, so there was evidently much superfluous rainfall in the earlier years.

The record wet summer was 1902 in all districts, except the west-central, where the summer of 1875 was the wettest, and the northwest, where the summer of 1900 was the wettest; and the wettest district was the central in 1902 with 26.21 inches. (Fig. 9.) The record dry summer was 1886 in all but the southwest district, where the driest was 1911, with 4.40 inches, and the southeast, where the driest was 1894, with 3.97 inches; and the driest district was the central in 1886, with 2.64 inches. (Fig. 10.) In extreme variation of summer rainfall the central district leads with a range of 26.21 inches, and the northwest district is least with 13.26 inches. (Fig. 11.) This small variation in rainfall, combined with a drouth-resistant soil, explains the dependability of the northwest district in corn production. At the end of the trend period in 1927 the northwest district has 38 per cent of its annual rainfall in the summer, leading in this feature over all the other districts, while the east-central district has the least, 33 per cent. At the beginning of the period the west-central district led with 44 per cent, and the east-central and southeast were least with 37 per cent.

SUMMARY

Iowa is becoming steadily drier, but up to this time the tendency has not proceeded far enough to threaten its principal crop, corn; in fact, conditions for corn seem to be improving. There is, no doubt, a limit, but probably the trend will change before the danger line for corn is reached.

ALIGNMENT DIAGRAM FOR "R" OF THE ENERGY-EVAPORATION EQUATION

By N. W. CUMMINGS

[Scripps Institution of Oceanography of the University of California, La Jolla, Calif.]

The evaporation from an open-water surface is determined by the relation (see Cummings and Richardson, 1927).

$$E=\frac{I-B-S-C}{L(1+R)} \qquad (1)$$

where (E) is the evaporation in centimeters of depth, during any arbitrary time, (I) is the energy which the sun and sky deliver to 1 square centimeter of the water surface during the same interval of time; (S) is the energy which accumulates during this time in a column of water having an area of 1 square centimeter and a depth equal to the average depth of the water body, while (C) takes care of certain corrections which are usually small. (L) is the latent heat of water and (R) is the ratio of sensible heat swept away by the wind to latent heat carried off by the vapor. Bowen (1926) shows that (R) can be calculated by means of the equation

$$R=.46\frac{T_w-T_a}{P_w-P_a}\frac{B}{760} \qquad (2)$$

where (T_w) is the temperature of the water surface, (T_a) that of the dry bulb, (P_w) the pressure of saturated water vapor at temperature (T_w), while (P_a) is the absolute humidity in millimeters of mercury, and (B) is the barometric pressure.

In order to facilitate numerical applications an alignment diagram was constructed by the following method:

Assuming $B=760$ the equation may be written in the determinant form

$$\begin{vmatrix} 1 & R & 0 \\ P_a & .46T_a & 1 \\ P_w & .46T_w & 1 \end{vmatrix}=0 \qquad (3)$$

Making use of the fact that the elements of any row or column can be added to the element of any other row or column without changing the value of the determinant, we add the elements of the first column to those of the last, obtaining

$$\begin{vmatrix} 1 & R & 1 \\ P_a & .46T_a & 1+P_a \\ P_w & .46T_w & 1+P_w \end{vmatrix}=0 \qquad (4)$$

Making use of the further fact that the effect of multiplying or dividing all the elements of any column or row by the same number is to multiply or divide the determinant

by that number, we divide the second row by $(1+P_a)$, and the third by $(1+P_w)$, thus obtaining

$$\begin{vmatrix} 1 & R & 1 \\ \frac{P_a}{1+P_a} & \frac{.46T_a}{1+P_a} & 1 \\ \frac{P_w}{1+P_w} & \frac{.46T_w}{1+P_w} & 1 \end{vmatrix} = 0 \qquad (5)$$

It is a property of determinants that if any two rows are interchanged the sign of the determinant is changed. We can therefore interchange the first and third rows, and the the first and second rows of the resulting determinant, obtaining finally

$$\begin{vmatrix} \frac{P_a}{1+P_a} & \frac{.46T_a}{1+P_a} & 1 \\ \frac{P_w}{1+P_w} & \frac{.46T_w}{1+P_w} & 1 \\ 1 & R & 1 \end{vmatrix} = 0 \qquad (6)$$

By adopting the following three pairs of equations

$$\begin{aligned} x_1 &= \frac{P_a}{1+P_a} & y_1 &= \frac{T_a}{1+P_a} \\ x_2 &= \frac{P_w}{1+P_w} & y_2 &= \frac{T_w}{1+P_w} \\ x_3 &= 1 & y_3 &= R \end{aligned} \qquad (7)$$

we can write equation (6) in the form

$$\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = 0 \qquad (8)$$

If the three points (x_1y_1), (x_2y_2), and (x_3y_3) lie on a straight line, their coordinates must satisfy the equation

$$\frac{y_3-y_1}{x_3-x_1} = \frac{y_2-y_1}{x_2-x_1} \qquad (9)$$

But equations (8) and (9) are really only two forms of the equation

$$x_1y_2+x_2y_3+x_3y_1-x_3y_2-x_2y_1-x_1y_3=0$$

Consequently any three points whose coordinates satisfy equation (8) must lie on a straight line.

If, therefore, three loci are platted, one for each pair of equations (7), and if a straight line is laid across these loci, it will intersect them in three points which, taken as a set, satisfy equation (6). But since equation (6) is equivalent to the original equation (2), the three points of intersection must also satisfy equation (2).

If we adopt an arbitrary wet-bulb temperature, (P_a) becomes definite whenever the dry-bulb temperature is known, and (P_w) is, of course, determined by the water-surface temperature alone. We might therefore construct the chart after computing Table 1 by proceeding as follows:

1. Adopt an arbitrary wet-bulb temperature and plot the first pair of equations (7) regarding (T_a) as a variable parameter.

2. Choose a different wet-bulb temperature and repeat step 1. Repeat this for the entire range of wet-bulb temperatures.

3. Plot the locus of the second pair of equations (7) regarding (T_w) as the variable parameter. Call the resulting line the water-temperature locus. The necessary computations are shown in Table 1.

4. Plot the last locus from the equations $(x=1)$, $(y=R)$. Call this the (R) locus.

Actually it is unnecessary to plot the first pair of equations point by point because if the water temperature is equal to the wet bulb, then $R=-1$ for all dry-bulb temperatures. Therefore the lines of constant wet-bulb temperature must be straight and each must pass through the point on the water-temperature locus corresponding to the wet bulb to which the line belongs and also through the point on the (R) locus corresponding to $(R=-1)$.

The various points on the lines of constant wet-bulb temperature can easily be found by remembering that

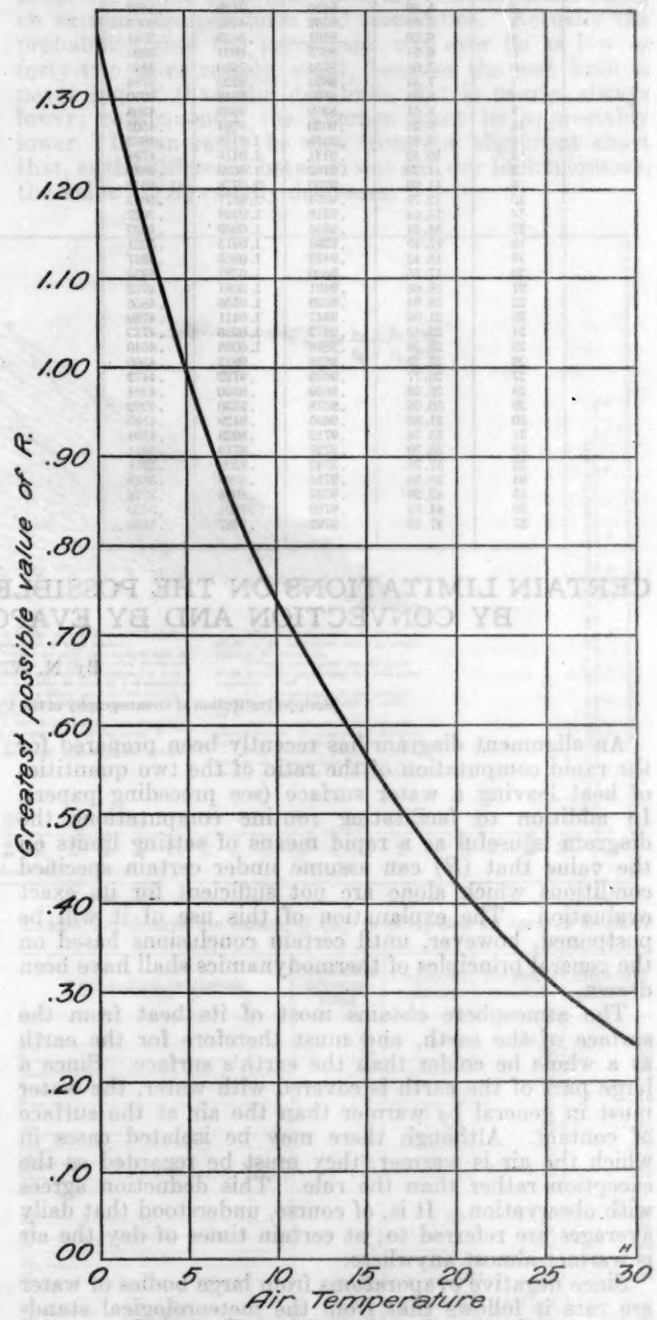

FIGURE 1.—Alignment diagram for the Bowen formula

when the air temperature and water-surface temperature are equal, (R) must be zero. Hence if straight lines are drawn through $(R=0)$ and through each degree point on the water-temperature locus they will intersect the wet-bulb lines at the appropriate dry-bulb temperatures.

The entire net can be plotted in this manner. All the loci are shown in Figure 1.

TABLE 1.—*Values of functions used in constructing the alignment diagram*

T_w=water temperature	P_w=vap. press.	$x=\frac{P_w}{1+P_w}$	$\frac{T_w}{1+P_w}$	$y=\frac{.46T_w}{1+P_w}$
0	4.58	0.8207	0	0
1	4.92	.8310	.1689	.0777
2	5.29	.8410	.3179	.1462
3	5.68	.8502	.4491	.2065
4	6.10	.8591	.5633	.2591
5	6.54	.8673	.6631	.3050
6	7.01	.8751	.7490	.3445
7	7.51	.8824	.8225	.3784
8	8.04	.8893	.8849	.4070
9	8.61	.8959	.9365	.4308
10	9.21	.9020	.9794	.4505
11	9.85	.9078	1.0138	.4663
12	10.52	.9131	1.0416	.4791
13	11.23	.9182	1.0629	.4889
14	11.99	.9230	1.0778	.4958
15	12.79	.9274	1.0877	.5003
16	13.64	.9316	1.0928	.5027
17	14.54	.9356	1.0939	.5032
18	15.49	.9393	1.0915	.5021
19	16.49	.9428	1.0863	.4997
20	17.55	.9460	1.0781	.4959
21	18.66	.9491	1.0681	.4913
22	19.84	.9520	1.0556	.4856
23	21.09	.9547	1.0411	.4789
24	22.40	.9572	1.0256	.4718
25	23.78	.9596	1.0088	.4640
26	25.23	.9618	.9912	.4560
27	26.77	.9639	.9722	.4472
28	28.38	.9659	.9530	.4384
29	30.08	.9678	.9330	.4292
30	31.86	.9695	.9129	.4199
31	33.74	.9712	.8923	.4104
32	35.70	.9727	.8719	.4011
33	37.78	.9742	.8509	.3914
34	39.95	.9755	.8302	.3819
35	42.23	.9768	.8096	.3724
36	44.62	.9780	.7891	.3630
37	47.13	.9792	.7687	.3536

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CERTAIN LIMITATIONS ON THE POSSIBLE VALUES OF THE RATIO OF HEAT LOSSES BY CONVECTION AND BY EVAPORATION AT A WATER SURFACE

By N. W. CUMMINGS

[Scripps Institution of Oceanography of the University of California, La Jolla, Calif.]

An alignment diagram has recently been prepared for the rapid computation of the ratio of the two quantities of heat leaving a water surface (see preceding paper). In addition to facilitating routine computations the diagram is useful as a rapid means of setting limits on the value that (R) can assume under certain specified conditions which alone are not sufficient for its exact evaluation. The explanation of this use of it will be postponed, however, until certain conclusions based on the general principles of thermodynamics shall have been drawn.

The atmosphere obtains most of its heat from the surface of the earth, and must therefore for the earth as a whole be colder than the earth's surface. Since a large part of the earth is covered with water, the water must in general be warmer than the air at the surface of contact. Although there may be isolated cases in which the air is warmer, they must be regarded as the exception rather than the rule. This deduction agrees with observation. It is, of course, understood that daily averages are referred to; at certain times of day the air is warmer almost anywhere.

Since negative evaporations from large bodies of water are rare it follows that from the meteorological standpoint positive values of (R) are more interesting than negative. Negative values of (R) combined with positive evaporations tend naturally to eliminate themselves because when (R) is negative the water is almost sure to be warming rapidly and (R) is thus in the act of becoming positive, unless very cold water is being supplied rapidly. The discussion will be limited therefore to positive values of (T_w-T_a).

Under these conditions evaporation rather than condensation is taking place. For any given air temperature and water temperature, then, (R) will be a maximum when wet and dry bulb temperatures are equal, because this condition makes (P_a) a maximum and therefore makes the denominator of the fraction a minimum, making the fraction as a whole a maximum. It follows that for the purpose of estimating (R_m), the maximum value of (R), (P_a) may be regarded as the pressure of saturated vapor at the temperature of the dry bulb.

For a given air temperature when wet and dry bulb are equal, (R) must increase as (T_w) decreases. This is evident from the fact that for saturated vapor $\frac{\Delta p}{\Delta t}$ decreases as the temperature (t) decreases and consequently reaches a minimum at the limit $\frac{dp}{dt}$. For any given air temperature, therefore, we may easily determine the greatest possible value of (R) by dividing .46 by $\frac{dp}{dt}$.

This derivative or the corresponding (R) may be computed in various ways:

(1) Directly from a table of saturated vapor pressures. This can be done most accurately by numerical differentiation, as described by von Sanden.

(2) From the well-known Clapeyron equation

$$L=t(v_1-v_2)\frac{dp}{dt}$$

(3) By the aid of a variety of empirical equations. The following empirical equation was worked out by Doctor McEwen. It is based upon tabular values of saturated vapor pressures corresponding to a series of absolute temperatures, t.

$$\frac{dp}{dt}=0.48393-0.005570t+0.0021111t^2-0.00001446664t^3$$

(4) The point at which the (R) locus of the alignment diagram is intersected by a line drawn tangent to the water-temperature locus at the point corresponding to the given air temperature represents the required value of (R).

The values of (R_m) obtained by these different methods are entered in Table 1. The relation between air temperature and (R_m) is shown by Figure 1. It is interesting to note that when the air temperature is 0° C. (R_m) is 1.38. Monthly air temperatures as low as 0° C. are usually not important from the standpoint of evaporation for two reasons:

(1) They occur only during the colder months and then only over a small part of the earth's surface.

(2) Under such conditions the vapor pressure of the water and, therefore, the evaporation rate are always small.

If we ignore all cases in which the air temperature is less than 0° C. and also those cases in which cold water is streaming through the volume under any particular area considered, we may say that the average evaporation from the area for a long period of time is never less than $\frac{1}{2.38}=42$ per cent of the evaporating power[1] of the excess of incoming over outgoing radiation. If, on the other hand, we ignore negative values of (R) and those cases in which warm water is streaming through the region, then the average evaporation over a long period of time is never greater than 100 per cent of the evaporating power of the net radiation.

Consequently, subject to the limitations specified, the evaporation must always lie between 42 per cent and 100 per cent of the evaporating power of the net radiation. It should be observed that these are extreme limits based on extreme temperatures and humidities. Actually the probability that the percentage will ever be as low as forty-two is extremely small, because the wet bulb is never higher than the dry bulb, but is nearly always lower; consequently the average must be appreciably lower. It can easily be seen from the alignment chart that, as the difference between wet and dry bulb increases, the value of (R) rapidly decreases.

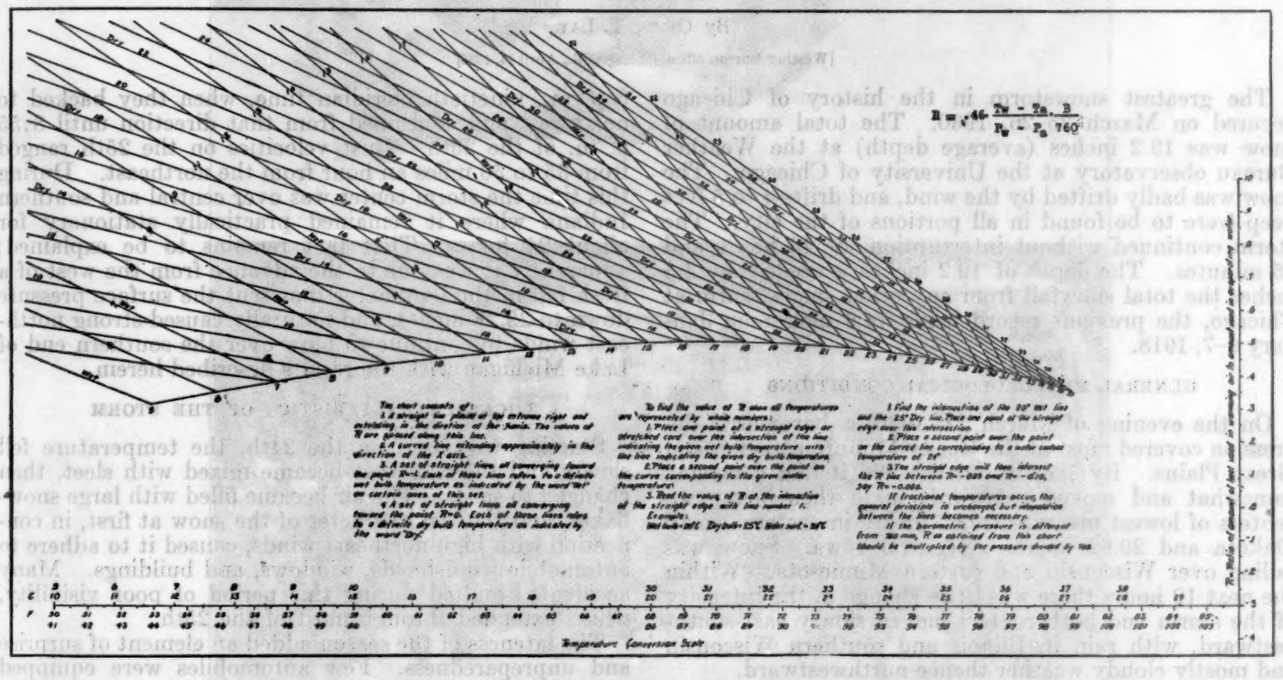

TABLE 1.—*Maximum values of (R) as computed by various methods*

Temperature, centigrade	Numerical differentiating	Clapeyron equation	Empirical equation	Alignment diagram
5	1.00	1.00	0.91	0.98
6	.95		.88	.93
7	.89		.85	.91
8	.84		.83	.86
9	.79		.78	.76
10	.74	.736	.74	.73
11	.70		.70	.70
12	.67		.67	.67
13	.63		.63	.63
14	.59		.59	.59
15	.57	.552	.57	.57
16	.53		.53	.53
17	.50		.50	.49
18	.47		.47	.46
19	.44		.44	.43
20	.42	.418	.42	.42
21	.40		.40	.40
22	.38		.38	.37
23	.36		.36	.34
24	.34		.34	.34
25	.32	.318	.32	.32
26	.31		.31	.31
27	.29		.29	.28
28	.28		.28	.27
29	.27		.27	.26
30	.25	.244	.25	.25

[1] This term is used by McEwen (1929, p. 244) to denote the evaporation equivalent of a definite quantity of energy, regardless of whether in the process considered the energy is all spent in evaporation or not. He applies the term to intensity of radiation penetrating the surface, signifying by it the depth of water which would be converted into vapor in unit time if all the penetrating radiant energy were dissipated by that process. The term is here applied to the excess of incoming over outgoing radiation. In the former case it is I/L, but in the present instance it is (I−B)/L.

Richardson, Kimball, Angot, Abbot, and others have conducted investigations regarding the relation between the intensity of solar radiation at the outer limits of the earth's atmosphere and the intensity at the earth's surface. Although the problem is complex, some conclusions of great value have been drawn. It is probable that these conclusions, together with the limits which can be set on the values of (R), will be of great value in connection with theories of climatic change, particularly glaciation.

The kind interest which Doctor McEwen of this institution has taken in the preparation of this paper, and also the valuable suggestions he has offered, are gratefully acknowledged.

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CHICAGO'S GREATEST SNOWSTORM, MARCH 25–26, 1930

By OWEN T. LAY

[Westher Bureau office, Chicago, Ill., April 14, 1930]

The greatest snowstorm in the history of Chicago occured on March 25–26, 1930. The total amount of snow was 19.2 inches (average depth) at the Weather Bureau observatory at the University of Chicago. The snow was badly drifted by the wind, and drifts 4 to 5 feet deep were to be found in all portions of the city. The storm continued without interruption for 43 hours and 45 minutes. The depth of 19.2 inches exceeded by 4.3 inches the total snowfall from any other single storm at Chicago, the previous record being 14.9 inches on January 6–7, 1918.

GENERAL METEOROLOGICAL CONDITIONS

On the evening of March 22, 1930, a barometric depression covered most of the Rocky Mountain region and Great Plains. By 7 a. m. on the 23d it had deepened somewhat and moved eastward, there then being two centers of lowest pressure, 29.60 inches in eastern North Dakota and 29.62 inches in central Iowa. Snow was falling over Wisconsin and eastern Minnesota. Within the next 12 hours there was little change in the intensity of the storm and both centers moved slowly east-southeastward, with rain in Illinois and southern Wisconsin and mostly cloudy weather thence northwestward.

By the morning of the 24th the northern center had practically disappeared and the southern center had moved from southeastern Iowa to west-central Indiana, with little change in intensity. During the next 12 hours, ending at 7 p. m. on the 24th, the center had advanced to extreme eastern Ohio but appeared only as a loop in the isobar, while a new center had apparently developed over southeastern Missouri and advanced to southern Indiana.

During the next 12 hours, ending at 7 a. m. on the 25th, the center over southern Indiana remained practically stationary with an increase in intensity from 29.54 inches to 29.28 inches, while the eastern loop had disappeared. By evening the main center of the storm had advanced to western Lake Ontario, but another center was left over east-central Indiana. By the morning of the 26th the eastern center had advanced to extreme southern Quebec, Montreal, 29.04 inches, and the western center had moved north-northeastward to the Georgian Bay region, Parry Sound, 28.98 inches, and by the night of the 26th the eastern center had practically disappeared and the western center continued to move north-northeastward, Doucet, Quebec, 29.10 inches.

The heaviest snow at Chicago occurred on the 25th with strong northeast winds from off Lake Michigan. These winds persisted throughout the 25th up to about 6 p. m., ninetieth meridian time, when they backed to northwest and continued from that direction until 8:55 p. m. of the 26th. Gust velocities on the 25th ranged from 35 to 50 miles an hour from the northeast. During this time the storm center was over central and southern Indiana where it remained practically stationary for about 24 hours. That fact remains to be explained; apparently it was due to the advance from the west of a fresh fall in the barometer that sent the surface pressure down to 29.28 inches, and naturally caused strong northeast winds to continue to blow over the southern end of Lake Michigan with the results described herein.

LOCAL CHARACTERISTICS OF THE STORM

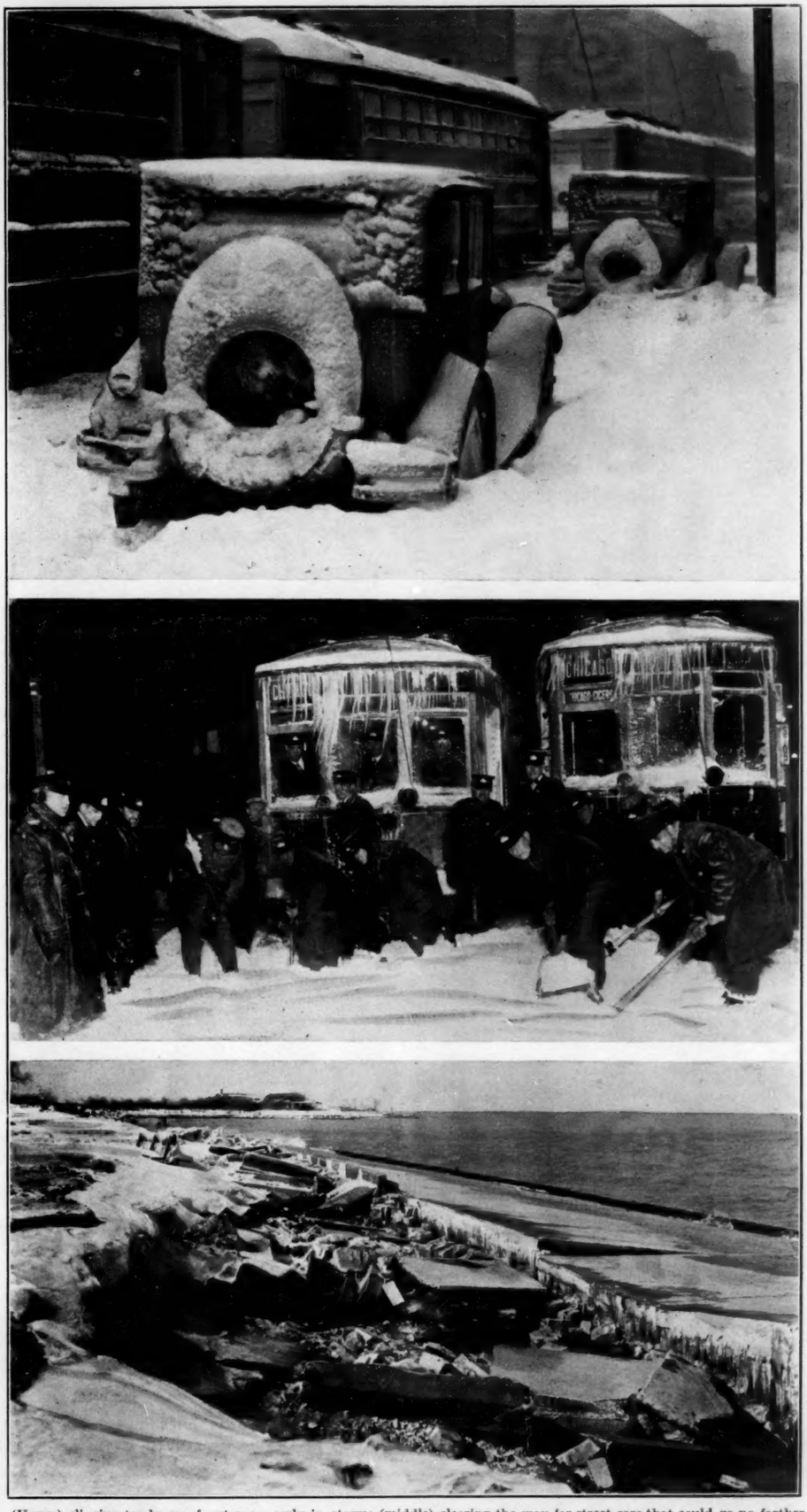
Starting with rain on the 24th, the temperature fell slowly and the rain first became mixed with sleet, then changed to snow. The air became filled with large snowflakes, and the wet character of the snow at first, in connection with high northeast winds, caused it to adhere to automobile windshields, windows, and buildings. Many accidents resulted during this period of poor visibility, which extended through most of the 25th.

The lateness of the season added an element of surprise and unpreparedness. Few automobiles were equipped with chains, and transportation organizations were not in readiness to combat the storm.

EFFECTS

The continued stalling of automobiles and trucks on car tracks made the constant operation of snow plows and street cars difficult or even impossible. Furthermore, automobile and truck traffic early in the storm served to pack the wet snow into soft ice that later had to be removed from street-car tracks by the use of picks and shovels. Many automobiles were abandoned in the streets. By noon on the 25th surface car service was practically at a standstill, suburban trains were moving with difficulty, and deliveries by motor vehicle had almost ceased. This imposed an extra burden upon the elevated lines, and that service was slowed up greatly because of the great crowds at the stations and on the trains.

Workers experienced much difficulty in reaching their places of employment and in returning to their homes on the 25th and 26th, and the down-town hotels were crowded. Many places of business closed early to enable their employees to reach their homes. In many cases those who came to work or returned home floundered through the snow for several miles to reach transportation that was moving on elevated tracks.



(Upper) clinging tendency of wet snow early in storm; (middle) clearing the way for street cars that could go no farther into drifted snow; (lower) damage shown along the lake front after most of the snow had melted. Wind damage lost sight of in most of the accounts of the storm because of the more spectacular struggle against the snow. (All three photographs the courtesy of Chicago Evening American, March 28, 1930).

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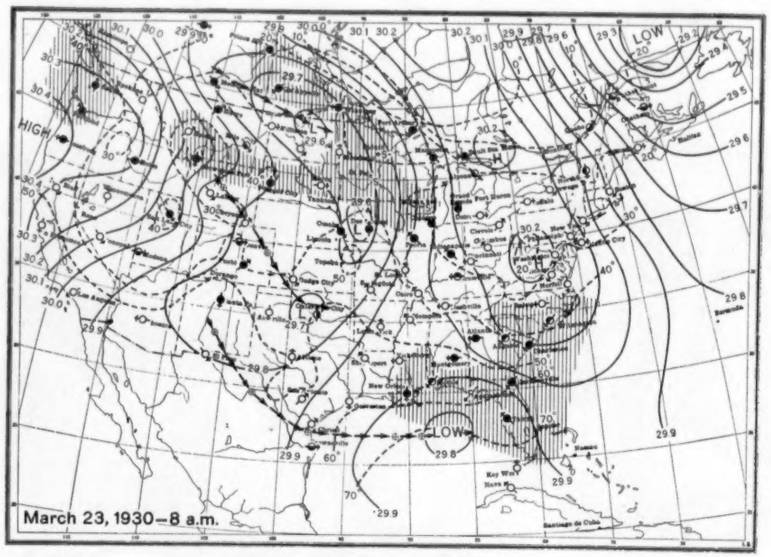


FIGURE 2.—Weather chart March 23, 1930

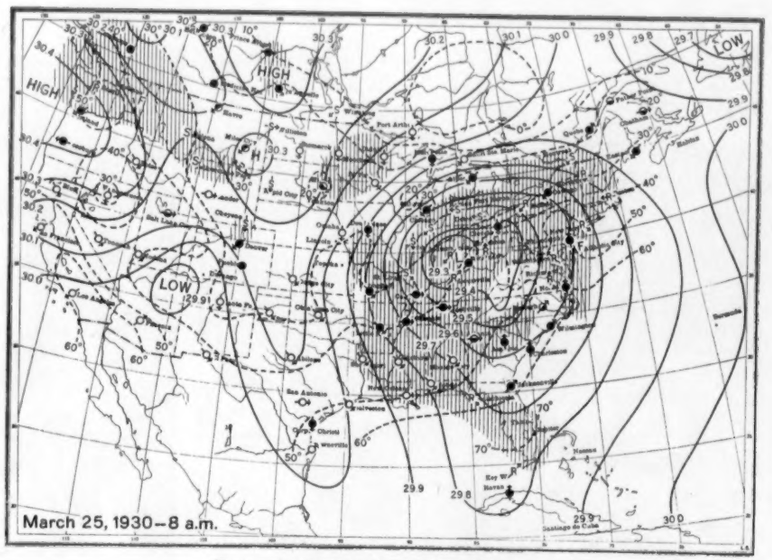


FIGURE 4.—Weather chart of March 25, 1930

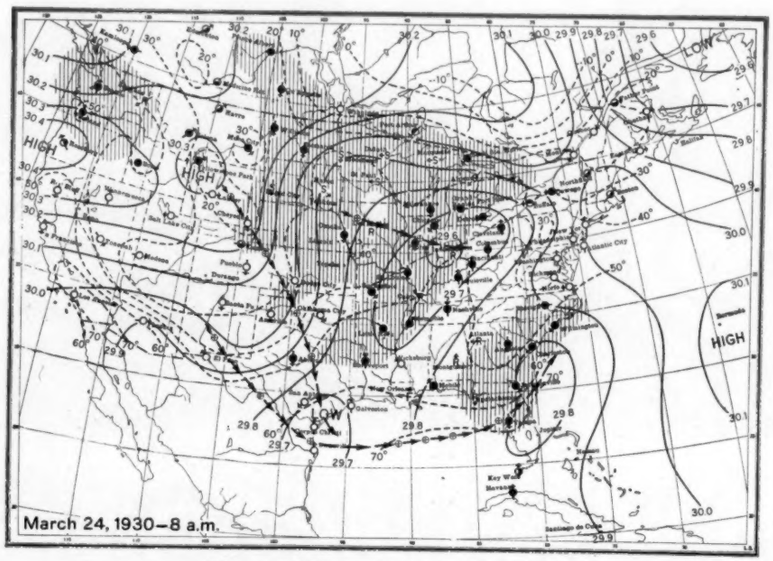


FIGURE 3.—Weather chart of March 24, 1930

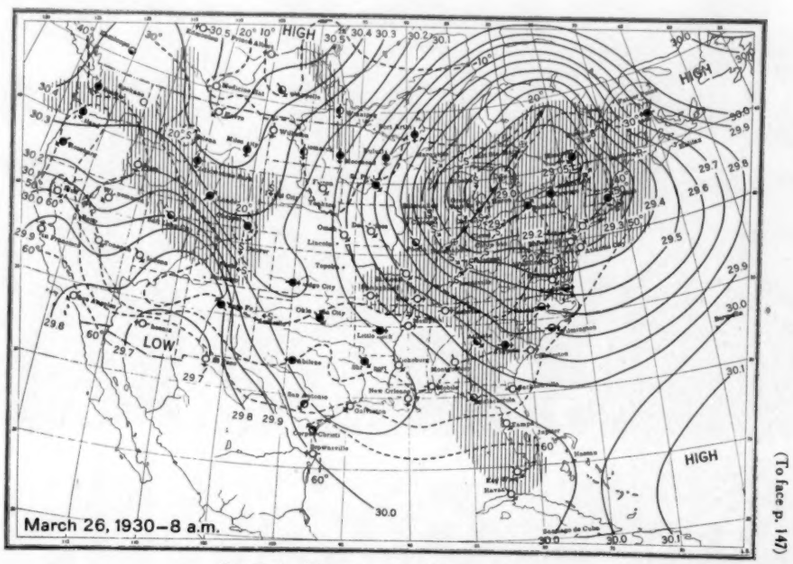


FIGURE 5.—Weather chart of March 26, 1930

(To face p. 147)

School attendance was small on the 25th, and the city schools were closed on the 26th and 27th. On the first day of the storm milk deliveries to the city were cut down about 40 per cent, and appeals were broadcast by radio for farmers and others who ordinarily deliver milk to make every effort to reach the city and thereby prevent a milk famine. Milk valued at about $40,000 was lost on the highways the first day of the storm.

Airplane traffic ceased for three or four days, because of poor visibility the first two days and the fact that great drifts of snow were left on the landing fields, and the runways had to be cleared before planes could take off or land. At Waterman, Ill., about 50 miles west of Chicago, the total depth of snow was only 3 inches, and one of the transcontinental lines used the emergency landing field there as a base for mail that was handled between Chicago and that place by train.

Stocks of some goods became low or even exhausted in many outlying stores that depended upon trucks for frequent deliveries. This was particularly true as regards bread and perishable vegetables.

Citizens in all sections of the city and in the surrounding territory spent many hours in clearing walks, alleys, and driveways, but little permanent relief was possible until after the snow and high wind had ceased on the night of the 26th.

The Chicago Surface Lines, possibly the greatest sufferer, employed as many as 20,000 men with picks, shovels, and all available mechanical equipment in digging the tracks out. The storm cost that organization approximately $1,000,000. Other organizations and individuals were required to expend much money and effort on account of the storm. Stocks of tools for handling snow and ice became exhausted in many stores, and automobile repair shops were kept busy in replacing broken springs, burned out clutches, and other repair work. It seems safe to state that the storm cost the community several million dollars.

Considerable damage was caused along the lake front by the pounding of waves during the early portion of the storm when strong northeast winds prevailed, but this effect was lost sight of in reports at the time because of the more spectacular snowstorm.

The snow disappeared quickly, and without flooding. This was possible because the ground under the snow was fairly dry and not frozen, the great amount of evaporation owing to low relative humidity following the storm, and the fact that the temperature was slow in rising above the freezing point.

DISCUSSION

For some years I have been greatly interested in pronounced abnormalities in the weather. The heavy snow described by Mr. Lay in the preceding article must be considered as one of the greatest abnormal snows east of the Mississippi in the last half century. The March, 1888, blizzard, as it is frequently called, is another striking example of very heavy snow in late winter. The two storms had some points in common and differed materially in others. The area of heavy snow and its maximum depth in the Chicago storm was much less than in the March, 1888, storm. A depth of 40 inches and more in the last named was registered over a considerable area in Connecticut and the area affected by the storm was tenfold to twentyfold greater than was the case in the Chicago storm. Points of similarity are as follows: The great depth of snow in both storms was due to the retardation of the storm's progressive motion eastward due to strong areas of high pressure to the northeastward. Both storms developed great intensity from the trough form of barometric depression.

It is convenient to consider the Chicago storm from the view-point of surface-pressure distribution as influenced by the free-air temperature directly above the storm center. (Fig. 2.)

Weather chart March 23, 1930.—The most significant feature of this chart is the crescent-shaped depression of the barometer that extends from Canada to Mexico east of the Rocky Mountains with three centers of low pressure as shown. This depression is flanked on both the east and the west by anticyclones of considerable magnitude but great contrasts of temperature on the surface at least, are missing.

From the forecast division's upper-air chart I glean the following: The winds above the barometric depression were from a southerly direction in the free air up to the 1,500-meter level (4,900 feet). Above that level, at 2,000 meters (6,600 feet), some of the southerly winds at the 1,500-meter level have become west winds but the northerly component continues at about half the stations. The velocities of these winds from the south at 2,000 meters ranged from 10 meters per second, hereinafter abbreviated to m. p. s., over North Dakota, to 16 m. p. s. over southeastern Kansas, which regions conform in a general way with the centers of lowest pressure; from this fact two assumptions are justifiable, first, a mass of warmer air overlies and is partly the cause of the low surface pressure and, second, since the winds from the south begin to thin out above 1,500 meters, the seat of energy of the cyclone must be at or near that level.

The upper-air chart for 8 p. m. of the 23d shows that the area of southerly winds has progressed toward the east, though not at precisely the same speed as the surface barometric depression. The surface wind-shift line has made but little progress eastward because of the presence of a secondary circulation centered over north-central Minnesota. Evidence of this secondary is found in the loop far to the northwest of the isobar of 29.90 inches on the chart for March 24.

Weather chart March 24, 1930 (fig. 3).—This chart shows a change in the orientation of the depression of the morning of March 23, the longer axis of which now trends northeast-southwest with its center over central Indiana. There is also considerable surface warming in the Ohio Valley and doubtless in the free air above the center of lowest pressure where winds from a southerly direction continue but have spread somewhat to the eastward of the low-pressure center.

Weather chart March 25, 1920 (fig. 4).—The significant feature on this chart is a fall in pressure at the center of the cyclone and consequently an increase in the barometric gradients especially those in the northwest sector of the cyclone. At this time the cyclonic circulation also seems to have bored upward to a greater height than previously indicated by the free-air winds. The surface wind at Sault Ste. Marie, Mich., was from the northeast as required by the cyclonic circulation; at 3,300 meters (10,827 feet) it was from the east with a speed of 16 m.p.s., still cyclonic. Elsewhere the surface winds and those up to 2,000 meters were still from a southerly direction although at some points a shift to westerly had taken place. From this it may be inferred that the center of the cyclone in the free air was somewhat displaced toward the northwest.

Weather chart March 26, 1930 (fig. 5).—Here we have an example of a vast cyclonic whirl that has become of

exceptional extent and intensity almost in the center of the continent. Although the cyclone is figured as having two centers, one of 29.00 inches, the other of 29.05 inches one can not but wonder whether the real center is at either point. The cyclone extends in an east-west direction about 1,700 miles and in a north-south direction about 2,200 miles.

By the morning of the 26th the upper-air winds at 1,500 meters have changed from southerly to westerly as far east as the Atlantic coast. The velocities ranged from 10 to 20 m.p.s. At 3,000 meters still higher speeds were found, the maximum being 36 m.p.s. at Jacksonville, Fla., on the outskirts of the cyclone. The two centers shown on the chart for the 26th had disappeared by the morning of the 27th and pressure at the cyclone center had risen somewhat. Its course thence to the northeast was uneventful.—*A. J. Henry.*

GULF STREAM DAILY THERMOGRAMS ACROSS THE STRAITS OF FLORIDA[1]

By CHARLES F. BROOKS

[Clark University, Worcester, Mass., April 5, 1930]

SYNOPSIS

During the past four years the Gulf Stream has been subjected to investigation by sea-water thermographs on crossing ships. Details of temperature, including alternating masses of warmer and cooler water, diurnal ranges of temperature, and rapid changes in distribution, have been written on the thermograms to form an amazingly complex picture.

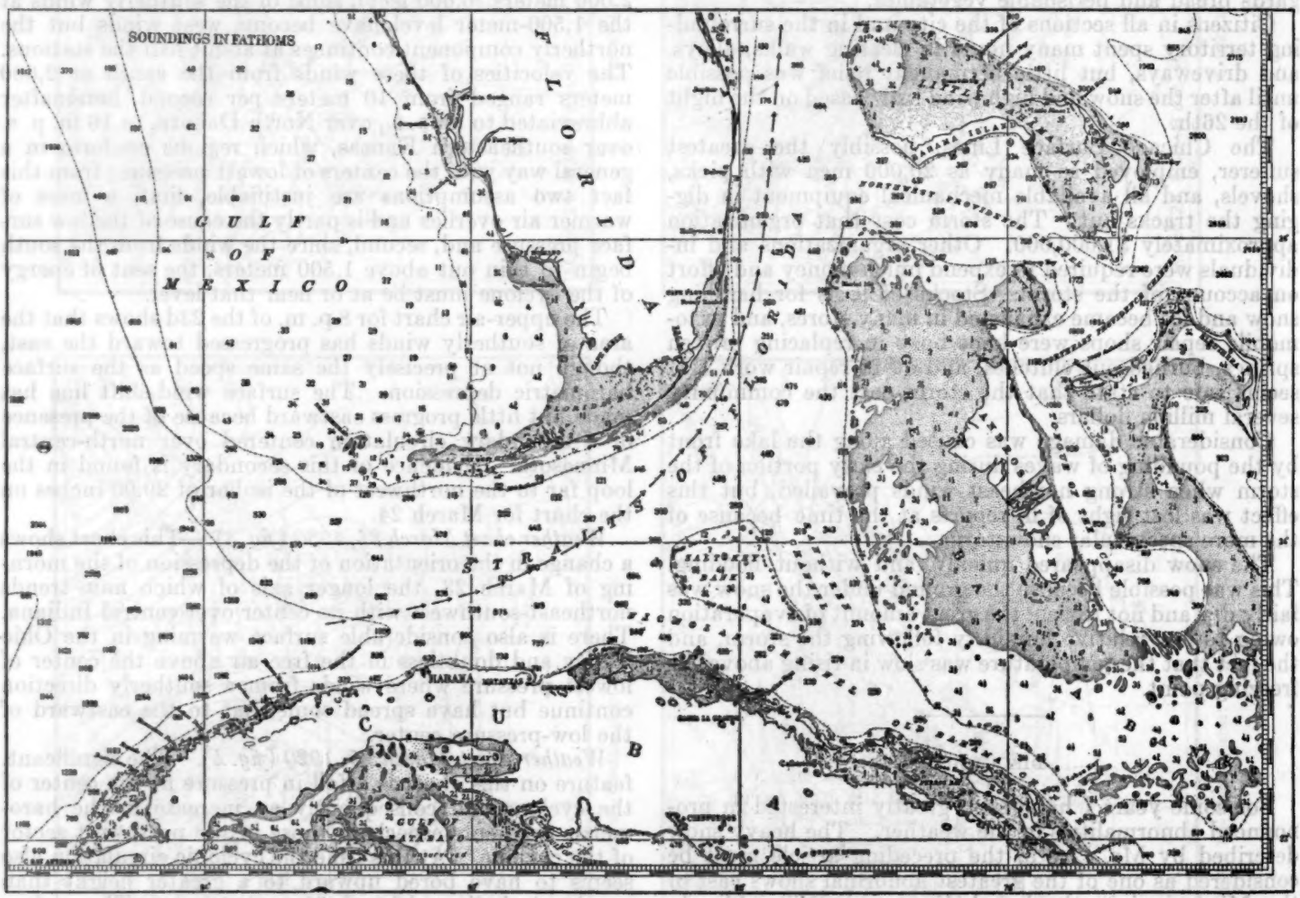


FIGURE 1.—Hydrographic features of the Gulf Stream within the Straits of Florida. (Adapted from United States Coast and Geodetic Survey Chart 1007 by the American Geographical Society for the *Geographical Review*, July, 1929.)

The thermograph is a mercury-in-steel bulb and capillary type, the thermal element being fixed in the intake pipe through which large volumes of water from several feet below the surface are continually pumped to the condensers.

An instrument of this sort installed in 1928 on the Peninsular & Occidental steamship *Henry M. Flagler*, one of the three Key West-to-Habana car ferries, provides the temperature record for one round trip daily while the ship is in operation. The southbound trip gives a night profile and the northbound a daytime one. From night to day in sunny quiet weather the sea temperature at the surface rises 3° or 4° F. and at a depth of 6 feet about 2°. In windy weather the diurnal range is reduced by stirring to 1° or less.

The summer profile is characteristically warmer in the north than in the south, while the temperature of Key West Harbor stands out several degrees above the Gulf Stream. A band of cool water is almost always traversed within a mile of the Cuban shore, apparently where swell and current striking the steeply sloping bottom bring cool water to the surface. Similar cool water often occurs likewise at the margin of shoal water south of Key West. The winter profile is usually 2° or more warmer in the south than in the north portion of the straits. A narrow zone of probably upwelling water several degrees cooler than on either side usually divides the warmer water from the cooler. This boundary shifts many miles with wind and other effects that bring at one time more water direct from the Caribbean and at another time from the Gulf. Great variations sometimes occur in the course of a few hours.

Storms, chiefly through their stirring action, reduce the surface temperatures by 1° or more. Strong cold winds have an even greater effect than hurricanes, for they chill the water considerably as well as mix the warm surface layer with the cooler substrata.

[1] Enlarged from paper presented at meetings of the American Meteorological Society, Des Moines, Iowa, Dec. 27, 1929, and the Association of American Geographers, Columbus, Ohio, Dec. 30, 1929. This is the first of a series of papers on The Gulf Stream and the Weather. (Cf. Gulf Stream Studies: General Meteorological Project, in the issue of the REVIEW of March, 1930.)

STRAITS OF FLORIDA SEA-SURFACE TEMPERATURE DATA HERETOFORE AVAILABLE

Observations of surface temperature made with the aid of canvas buckets are available for many years, both from ships passing through the straits and from the car ferries crossing them, but the spotty character and inherent inaccuracies prevent these data from being so informative as a continuous thermograph record.[2,3] Therefore, the thermograph record, beginning July, 1928, brief though it is, should be studied before any extensive reduction of the other data is attempted. Furthermore, the thermograph record may be used as a standard by which the bucket observations can be judged, both as to their accuracy and as to their adequacy, in showing the general surface temperatures of the Gulf Stream here. The special series of observations at certain intervals across the straits made by officers of the Peninsular & Occidental Steamship Co. car ferries *Henry M. Flagler* and *Joseph R. Parrott*, 1917–1921, were resumed in 1928, under essentially the same conditions, on these ships and the *Estrada Palma*. Thus the earlier series may be evaluated on the basis of the relation of the later one to the thermograph record. The usual bucket observations made on ships passing through the straits have continued practically unchanged, except as to number, for decades. These data, however, are almost exclusively from the left half of the stream, largely in the more quiet waters near the Florida coast and reefs. (See map, fig. 1.) The car-ferry and other ships' bucket records will be analyzed in later papers

THE SEA-WATER THERMOGRAPH AND WHAT IT RECORDS

The opportunity for obtaining a detailed record of daily temperature across the Straits of Florida between Key West and Habana led the American Meteorological Society to grant $188 for the purchase (including the 40 per cent duty) of a large-scale Negretti & Zambra sea-water thermograph. This was delivered in April, 1928, exhibited at the meeting of the society held that month, then turned over to the United States Weather Bureau, under whose immediate auspices the instrument was to be installed on a ship at Key West, Fla. Mr. H. B. Boyer, the bureau's official in charge there, had previously obtained permission of the Peninsular & Occidental Steamship Co. to place the instrument in one of its vessels. Installation on the regularly running passenger ship *Governor Cobb* proving impracticable, the instrument was finally put into car ferry *Henry M. Flagler*, W. I. Jackson, master, by Curtis H. Stanton, chief engineer, who was very much interested. The first record was obtained July 8, 1928. The loss of an opportunity to obtain a regular record on the passenger ship was compensated by getting the nighttime as well as daytime observations and by other advantages. The more nearly surface temperatures obtained on the car ferry than could be got on another ship shows the diurnal changes more prominently. Furthermore, the longer period special series of bucket observations on the *Flagler* could now be compared directly with the new thermograph intake record on the same ship. Unfortunately, however, each car ferry is laid up at not infrequent intervals for a month at a time. So, rather long gaps in the record were to be expected. It has not seemed feasible to move the instrument from one ship to another to avoid these periods of idleness. Instead, the purchase of thermographs for the other two car ferries is hoped for.

The thermograph (fig. 2) is of the mercury-in-steel bulb and capillary type, Negretti & Zambra's Model B. A brass well protects the bulb. The bulb has a capacity some 150 times that of the 10 feet of fine capillary, the bore of which is but 0.007 inch. For a change of temperature of the capillary of 20°, therefore, an error of a little over 0.1° only is introduced. The capillary ends in a Bourdon tube, the curvature of which changes with the pressure of the mercury. The pen arm is fastened onto the free end of the Bourdon tube and is unencumbered by levers. The pen rests lightly on the drum, for the pen arm at its base has a hinge that slants enough to allow part of the weight of the pen and arm to bear on the record sheet. The sheet in this instrument is 5.8 inches high and 16.2 inches long, providing a fairly open scale both for temperature and time.

Tests of the thermograph were made by S. P. Fergusson and C. F. Brooks at Washington, April 27, 1928, showing it to read too low, by 0.5° F. at 67, 0.4° at 77, and 0.3° at 85. Another, by H. B. Boyer, July 28, after the instrument had been installed on the *Henry M. Flagler*, showed the thermograph 0.5° too low at 88.7. A series of 30 comparisons by C. F. Brooks, during a round trip across the straits, April 8–9, 1929, between the temperature of the water coming from the faucet on the intake pipe and that being recorded by the thermograph, showed the thermograph too low at temperatures from 76° to 79° F. by 0.6° F. 3 times, 0.7° 24 times, and 0.8° 3 times. After allowing for the sheet having slipped up from the basal flange 0.2° of scale, the error averaged 0.5°, essentially as before. Since these tests in April, C. H. Stanton has compared the thermograph record with a calibrated thermometer each week. Without exception during the past 10 months at temperatures between 75° and 90° F. the thermograph has continued 0.5° F. too low. No attempt has been made to adjust the instrument for so small an error, the stability of which makes correction of tabulations easy.

How the thermograph is installed.—The installation of an instrument of this kind on a steamship is not always practicable. The bulb must be placed in flowing water and the recorder set close by so there will not have to be too much capillary. To fix an exposure on the outside of a ship is a dry-dock job. The main intake for the condensers provides a great volume of water immediately from the sea, and has been found to be the most satisfactory position for the thermograph bulb.[4, 5, 6]

On the *Governor Cobb* installation was not practicable because nearly all the intake pipe is in the bilge and below the deck plates; the only available point was where the steam enters the condenser. Moreover, the pipe is of cast bronze, which, if tapped, would require brazing in dry dock. On the *Henry M. Flagler*, however, no such difficulties presented themselves. On the inner portion of the sea-valve casting, where the intake pipe joins it, a 1-inch hole was drilled to admit the well in which the steel bulb closely fits. (Fig. 3.)

[2] Charles F. Brooks. Observing Water-Surface Temperatures at Sea. MONTHLY WEATHER REVIEW, June, 1926, 54: 241–254, inclusive, discussion by several, and comment by F. G. Tingley.

[3] Charles F. Brooks. Reliability of Different Methods of Taking Sea-Surface Temperatures. Jour. Washington Acad. Sci., Dec. 4, 1928. 18: 525–545.

[4] Sir Frederic Stupart, J. Patterson, and H. Grayson Smith. Ocean Surface-Water Temperatures—Methods of Measuring and Preliminary results. *Bull. of the National Research Council*, No. 68, Washington, 1929, pp. 76–88, especially 78–80, figs. 1 and 2.

[5] Charles F. Brooks. Notes on the Extension of the Use of Sea-Water Thermographs, and on How They have been Installed, in annual reports of the Committee on Submarine Configuration and Oceanic Circulation, National Research Council, 1927, 1928, 1929, and 1930 (mimeographed).

[6] Footnote 3, p. 535.

Mr. Stanton describes the position of the bulb as follows:

> It is placed in the suction pipe to the upper sea valve to the circulating pump of the main condenser on the pump side of the valve about 2 feet from the skin of the ship. We have a 12-inch centrifugal circulating pump which runs at about 225 revolutions per minute; there is no velocity lost in the speed of the water, as the pump is about 6 feet below the water line and the water flows to the pump. The sea cock is 6 feet below water line.

From the bulb the capillary follows a rib of the ship at about 10 inches from the skin on a slant upward to the recorder on a shelf. The recorder is bolted to a shelf which is itself bolted to the skin of the ship and is so placed that the pen arm is in a fore-and-aft position. (See fig. 3.) Owing to the damping by the sea, the effect of the engine vibration of the ship on the fineness of the record is negligible. But severe rolling doubles or trebles the 0.1° ordinary scale width of the record line. This is due in part to the pen swinging on its hinges away from the drum and back onto it. In mid-November, 1928, the pen swung against the glass window of the case and stuck, causing loss of record. The ship was at times rolling 36°, Mr. Stanton reported. After the ink was removed from the back of the pen and the glass cleaned no further trouble of this sort was experienced. On one of the trips the intake rolled out of water so much that the recorded temperature rose to 4° above that of the sea.

What the thermograph record represents.—The sea cock through which the condenser intake water enters is 6 feet below the surface on the average. This depth varies an average of 1 foot and a maximum of 2 feet [7] with the load of freight cars and a great deal with the amount of roll, possibly 8 feet at 35°, from 2 feet down to 10 feet below the surface. There is almost always enough ground swell to bring the intake now and then to appreciably less than the 6-foot depth. Thus the water is drawn from different levels of the top 8 or 10 feet. In rough weather and at night, when the water is well stirred, the temperature of the entire layer is the same as that at the surface, but on a calm sunny afternoon the water near the surface becomes 2° to 4° F. warmer than at a depth of several feet.[8] The afternoon of April 12, 1929, the record ranged over a degree from minute to minute, with an extreme of 1.7° F., apparently owing to the higher temperature of the surface though such differences may exist horizontally as well as vertically.[9] Similar ups and downs, amounting to 2.3°, July 2, and 2.4°, August 12, 1929, occurred in quiet weather. On the other hand, on a sunny day with a wind of Beaufort 2–3 and no appreciable sea, five surface observations by C. F. Brooks with the large canvas bucket, between 12:55 and 3:00 p. m., April 9, 1929, gave temperatures 0.2° below, no difference, and 0.1°, 0.1°, 0.1° F. above the corrected indication of the thermograph, or an average of no difference.

For 16 days when the thermograph record showed afternoon temperatures appreciably higher than the night temperatures, and for which bucket observations and wind data were available on the same ship, the following tabulation shows that in all but the very quietest weather the thermograph record indicates the surface temperature.

TABLE 1.—*Difference between bucket and thermograph records of sea temperature between 1:45 and 4:45 p. m. on days with large diurnal range of surface water temperature, April to August, 1929, between Key West and Habana. Steamship "Henry M. Flagler"*

Wind velocity	Number of—		Bucket temperature minus thermograph temperature at time of bucket observation						
			For mean reading of thermograph			For lowest swing of thermograph, mean	For highest swing of thermograph		
	Days	Bucket observations	Mean	Least	Most		Mean	Least	Most
			° F.	° F.	° F.		° F.	° F.	° F.
Very light (Beaufort 0)	6	11	1.0	0.2	2.6	1.4	0.6	−0.5	2.3
Light (Beaufort 1)	7	12	−.6	−1.7	.3	−.2	−1.0	−2.9	.1
Moderate (Beaufort 2)	3	6	−.7	−2.0	.8	−.3	−.8	−2.4	.3

Table I shows that on the calm days the temperature obtained with the canvas bucket averages 1° above that shown by the thermograph for water 6 feet below the surface, and that the surface temperature as observed in a sample drawn up in a bucket may be as much as 2.6° F. warmer than the intake water. The thermograph trace, however, shows marked fluctuations on such quiet days, which range on the average from 0.6° to 1.4° F. below the surface sample. The highest temperature recorded by the thermograph within a few minutes of the time of bucket observation ranges on calm days from 2.3° below the bucket temperature to 0.5° above.[10]

With even a light wind, the surface samples by bucket usually show temperatures lower than the intake thermograph by a mean of 0.6° and an extreme of 1.7° F. The depression of bucket temperature below the highest swing of the thermograph pen is nearly 3°. Corresponding values for moderate winds are almost the same. The fact that the bucket temperature is some half degree lower than the intake temperature when there is enough wind to stir the water is in accord with other observations,[11] and suggests that if, as likely, this cooling also affects the samples on calm days the actual temperatures of the surface range from 1° to 3° higher than those at the depths through which the car-ferry intake swings. Thus the thermograph records from the *Henry M. Flagler* are truly representative of the surface temperatures except on the rather rare calm days, when, during midafternoon hours, the surface temperatures may run from 1° to 3° above the intake.[12]

Notations on the thermograms.—Since the temperature of the water in the intake pipe is recorded continually

[7] Ordinary draft before loading is 12½ feet, average loaded draft, 14½ feet; maximum load draft, 16 feet, which is seldom reached.

[8] See references in footnotes 2, 3, and 5.

[9] Cf. Discussion of paper by Charles F. Brooks and Hazel V. Miller. Gulf-Stream Temperatures in the Straits of Florida, Bull. Amn. Met'l Soc., May 1929, 10: 107–110. Ref. top p. 110.

[10] This warmth on the surface is in accord with P. M. van Riel's paper, The Influence of Sea Disturbance on Surface Temperature (Kon. Ned. Met. Inst. Med. en Verh. 30, 1929. Note in Met. Mag. London, Feb., 1930, pp. 20–21. Surface temperatures average about 0.5° to 1° F. higher on quiet than on moderately rough days.

[11] See references in footnotes 1 and 2.

[12] Cf. footnote 4 and G. F. McEwen. Significance of Water-Temperature Measurements Not Made Exactly at the Surface. *Jour. Wash. Acad. Sci.*, Dec. 4, 1929, 18: 545–546.

FIGURE 5.—June 30 to July 7, 1929. An exaggerated example of the contrast in temperature in bright, quiet summer weather.
FIGURE 6.—June 8 to 15, 1929. Note the higher temperatures in shallow water and the diurnal range of two or three degrees.
FIGURE 7.—August 11 to 18, 1929. Late summer temperatures; shallow waters less contrasted with the deep.
FIGURE 8.—August 6 to 11, 1928. Even distribution of temperature in cloudy disturbed weather while hurricane was passing at a distance
FIGURE 9.—September 22 to 29, 1929. Regular course of temperature first of week replaced by falling temperature as hurricane passed close by on September 28
FIGURE 10.—October 6 to 13, 1929. Diverse sea temperatures in cool week after stirring by hurricane.

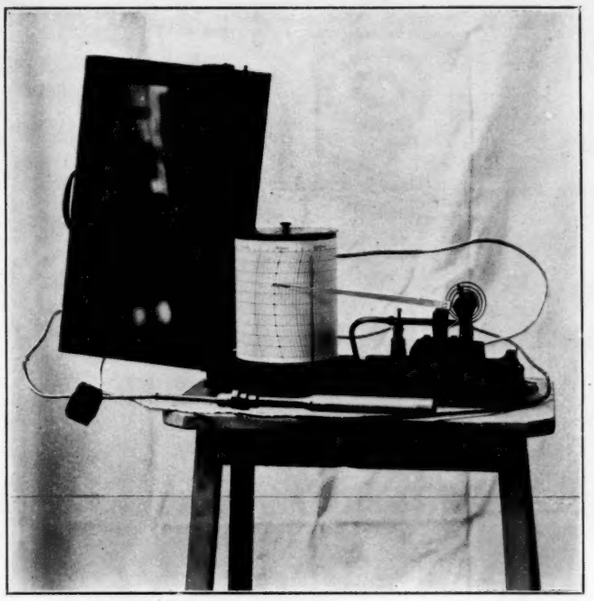


FIGURE 2.—The Negretti & Zambra, model B, sea-water thermograph. The bulb and capillary are filled with mercury. The coil on the recorder is a Bourdon tube, which changes curvature with change in pressure of the mercury. The pen arm is fastened directly to one end of the Bourdon tube, and is hinged to provide light contact with the drum

FIGURE 3.—The bulb, capillary, and recorder of sea-water thermograph on S. S. *Henry M. Flagler*, C. H. Stanton, chief engineer, Peninsular & Occidental S. S. Co. The bulb, in Mr. Stanton's hand, fits into a well that projects across the rapidly flowing stream of seawater which is pumped into the condensers of the steamship

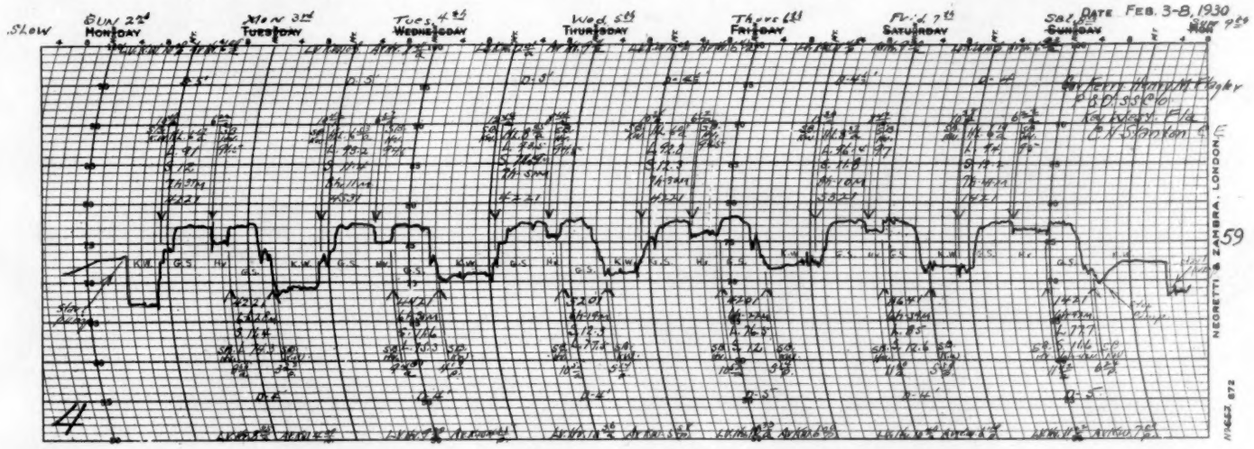
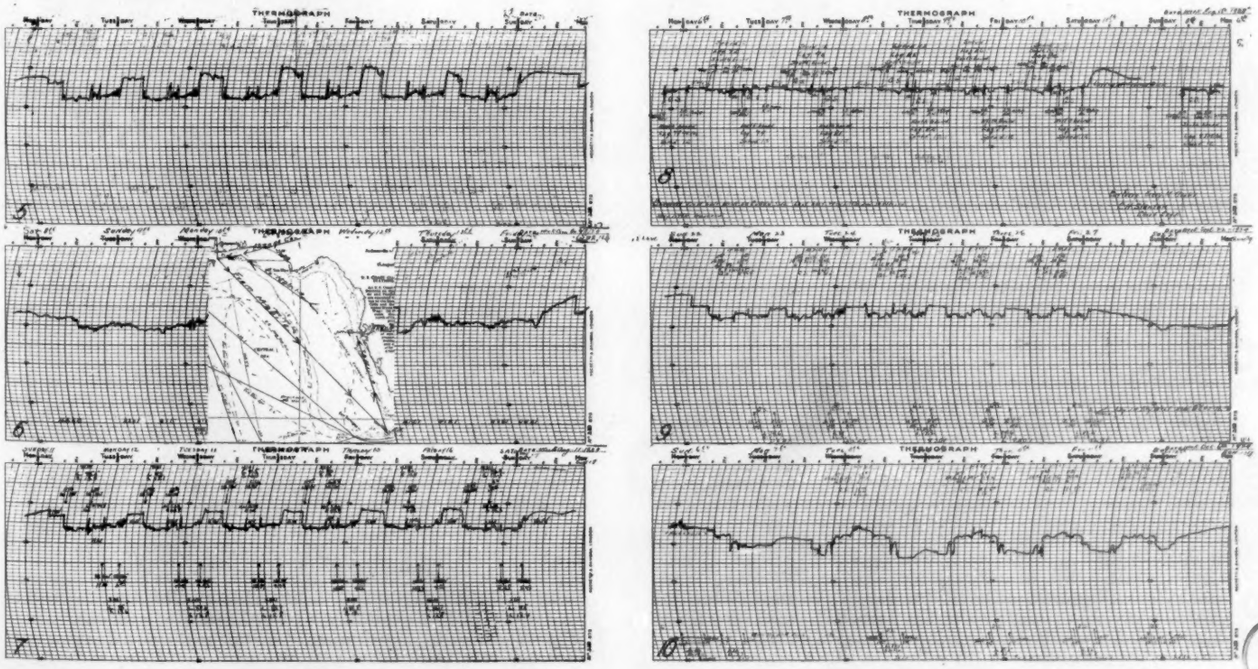


FIGURE 4.—A thermogram illustrating the notations used to indicate the supplementary data for the Key West to Habana seawater thermograms. The weather notations indicate southeasterly to southerly winds from the 2d to the morning of the 7th, with accompanying rising temperatures of the sea surface. At the end of the week the wind turned north and temperatures began to fall. Note the strong northwesterly wind of the 7th, and the 8 miles greater than usual logged mileage on the daytime return trip



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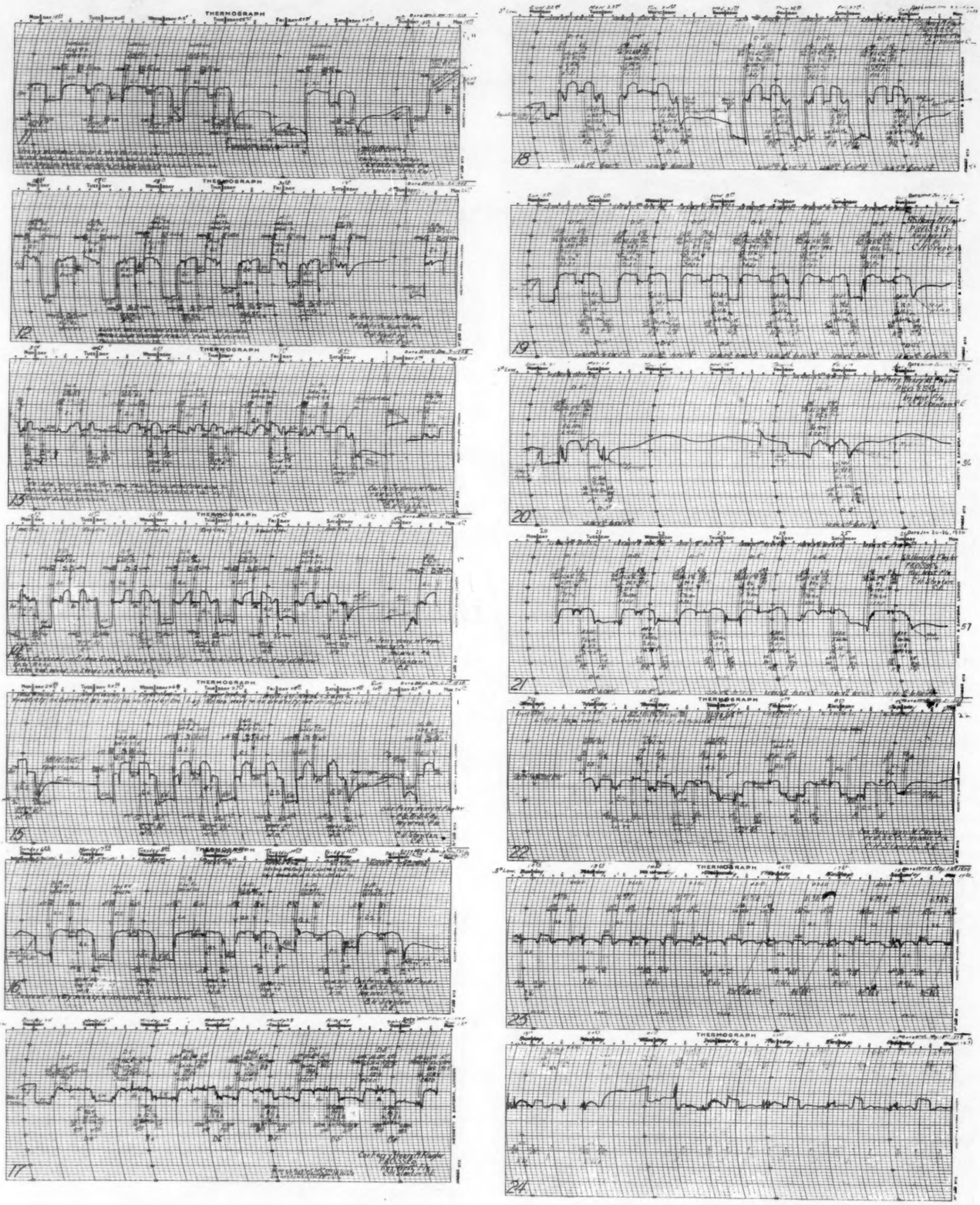

whether or not the ship is underway, notations as to dates and hours of arrival and departure of the ship are essential for accurate tabulation and use of the records. Mr. Stanton now gives the following information on the thermograms (see fig. 4):

Date.
Circulating pump started and stopped.
Hour and minute of departure and arrival at dock and when passing Key West sea buoy (S. B. K. W.) and Habana sea buoy, Morro Castle abeam (S. B. Hv.).
That portion of the trace showing the water between the Key West and Habana sea buoys (G. S., after Gulf Stream), and those while ship is at dock at Key West (K. W.) and Habana (Hv.).
Hour and minute when ship hauls in the patent log on arrival off Habana (H. L.). This is of special significance when the ship is on second run and must wait for the first ship to leave the harbor.
Logged mileage, sea buoy to sea buoy (L.), also, when ship stops off Habana, logged mileage from Key West Sea Buoy to hauled log position (H. L.).
Average speed of ship in knots from sea buoy to sea buoy, i. e., logged mileage divided by the number of hours ship was on its course (S.).
Depth of intake (D.), to nearest half foot.
Extended periods when ship is at dock either in Habana or Key West are noted.
Wind direction and force, roll of ship, and amount of seaweed each trip, a series of four numbers according to the following scales:

Wind direction (Beaufort notation)	Wind velocity (Beaufort scale)	Roll of the ship (Stanton's scale)	Amount of Gulf weed (Stanton's scale)
1=N. 2=NE., etc. 8=NW.	0=Calm. 1=Light airs, etc., to. 6=Strong breeze. 7=Moderate gale which is limit of safety for this car ferry.	0=No roll. 1=1 to 5 degrees roll. 2=5 to 15 degrees roll. 3=15 to 25 degrees roll. 4=25 to 35 degrees roll. 5=Above 35 degrees roll.	0=No weed. 1=Moderate presence of weed. 2=Lots of weed.

Clock errors: Pointers from sea buoy times to temperature line are as accurate as possible, and engineroom clock time is checked against thermograph every day.
Thermograph temperature checked every week by calibrated thermometer, and notation of variation made on upper left-hand margin of chart.
Weather or current conditions of special note are summarized on front or back of chart.

THE TEMPERATURE PROFILE AT DIFFERENT SEASONS

The temperature profile of the surface waters between Key West and Habana is a constantly changing one. At the different seasons, however, it has certain features characteristic of the time of year which tend to recur day after day. In summer, high temperatures at Key West and flatness of the Gulf Stream profile are characteristic. In winter, low temperatures at Key West, moderate ones in the northern portion of the Straits and appreciably higher ones in the southern are usually in evidence. In spring, there are alternations between winter and summer types; and in autumn irregular types occur, especially after the passage of a hurricane. In the following paragraphs samples of profiles will be presented and some interpretation made. A detailed study of the distribution of temperatures and its relation to the previous and present weather, however, must await a larger body of records.

Summer temperature profiles.—The thermogram for June 30 to July 7, 1929 (fig. 5), is an exaggerated example of the contrasts in temperature that commonly develop in summer. The high temperatures of the more quiet waters of Key West Harbor and reefs and of Habana Harbor and its narrow entrance, on either side are sharply differentiated from the somewhat lower ones of the moving and stirred Gulf Stream. The spires of high temperature in Habana Harbor and the plateaus of still higher temperature in Key West Harbor are features of the temperature profiles practically throughout the warmer half year. The Habana maxima occur in the central portion of the larger part of the harbor, and are higher than the temperatures at the dock, because of the dock shadows and greater stirring near shore.[13] The maxima between Key West sea buoy and the harbor are, similarly, in the more heated shallow water. Thus, on the afternoon of April 10, 1929, the writer observed a temperature rise from 78.3° F. in the blue water to 79.8 as the car-ferry *Joseph R. Parrott*, on which he was riding, passed a sharp boundary into green water half a mile inside the sea buoy which is at the 20-fathom line.

Close by these prongs of high temperature on the Habana side are sharp depressions, best developed in fig. 5 on July 6, which mark the contact of swell and current [14] with the bottom a short distance from the shore. Eye observation of intake temperature every two or three minutes by C. F. Brooks on the *Henry M. Flagler*, April 9, 1929, showed the lowest temperature about a mile from the sea buoy at the entrance of Habana Harbor, or somewhat under a mile off-shore.

[13] Water in Habana Harbor has practically no circulation, as there is but one narrow entrance and very few shallow spots, being all dredged out and deep (average 25 feet right up to land). The tides here average less than a foot (0.9 foot) mean, 1.3 feet maximum according to "Tide Tables United States and Foreign Ports, 1930," U. S. Coast and Geodetic Survey, Washington, D. C., 1929).

[14] John E. Pillsbury. The Gulf Stream. Methods of investigation and results of research. Report of the Superintendent, U. S. Coast and Geodetic Survey, year ending June 1890, Appendix 10. Washington, 1891, pp. 461-620. Refer to p. 596.

FIGURE 11.—November 18 to 25, 1928. A norther cools the harbors and begins to cool the Gulf Stream.
FIGURE 12.—November 26 to December 2, 1928. Cool streaks of falling temperature in Gulf Stream after a strong norther.
FIGURE 13.—December 2 to 8, 1928. A quiet week, with recovery of harbor temperatures and widening of warm portion of Gulf Stream.
FIGURE 14.—December 9 to 15, 1928. Another norther temporarily reduces width of warm portion of Gulf Stream from 40 to 15 miles.
FIGURE 15.—December 23 to 29, 1928. A week of much contrast but practically no current.
FIGURE 16.—January 6 to 12, 1929. Mid winter profiles—cooler north than south. (Cf. fig. 19.)
FIGURE 17.—November 24 to December 1, 1929. A quiet week in late fall with Gulf Stream temperatures as high as 81 running into the early days of December.
FIGURE 18.—December 22 to 28, 1929. A week of unusually cold northerly winds with consequent falling temperatures. Note the low temperature of 58.5 at the northern margin of the Gulf Stream the night of December 25–26, while only a mile or two away the temperature reaches 74. On this crossing the range was 20° in sea temperature. (Cf. figs. 12 and 15.)
FIGURE 19.—January 5 to 11, 1930. A slow recovery in sea temperature. Note that the usual cool northern portion of the Straits is virtually absent, though on the 11th a cool streak begins to develop appreciably. (Cf. fig. 16.)
FIGURE 20.—January 13 and 17, 1930. A wide band of cool water far from shore January 13 as center of a westward moving low passes, with brisk shifting winds.
FIGURE 21.—January 20 to 26, 1930. A quiet period in winter resembling springtime conditions.
FIGURE 22.—March 2 to 10, 1929. A springtime curve during a period of cool winds that temporarily reduced temperatures.
FIGURE 23.—May 12 to 19, 1929. The relative coolness of the north portion is still in evidence though scarcely less marked than the cool weather on the Cuban side. The flatness of this curve goes with a windy week.
FIGURE 24.—May 19 to 26, 1929. With cloudier conditions the Key West temperatures rose 2° and the Gulf Stream 10°, while daily ranges increased to 2° or 3°, a summer time condition.

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A prominent feature of the afternoon portions of the daytime return trips toward Key West is the widening of the temperature line to 1 to 2 or more degrees owing to considerable variations in temperature within intervals of a few minutes. The lowest temperatures on these swings of the pen are a half to 1 degree higher than the temperatures recorded for the same positions during southbound trip the preceding night, and this half to 1 degree rise appears to represent about the warming that has occurred during the day to a depth of 8 or 10 feet where the intake, with the rolling of the vessel, would probably catch its coolest water. The higher portions of the swings of the pen represent practically surface temperatures, as shown in the discussion of Table 1. July 1, the only calm day of the week, has the largest range of these afternoon swings of temperature—2.7°.

Even till midnight the waters remain fairly warm on the surface and spots or belts of cooler and warmer water seem to develop. On the nights of July 1 and 2 a small body or streak of warm water about 2° above the general run of temperature was encountered 6 and 8 miles off the Key West sea buoy.

The round trip of the *Henry M. Flagler* to Mobile early in June, 1929 (Fig. 6), showed the characteristic higher temperatures in shallow water between Key West and Tampa sea buoy, and a fall of 2.5° F. when the 10-fathom curve off Tampa was passed into deeper water. The diurnal range in temperature in the open Gulf June 9, 13, and 14, was about 2°, with an extreme range of 3° the 13th. The highest temperatures occurred at 2:30, 3:55, and 3:30 p. m. on these days and the lowest between 5 and 9 a. m. A southeast wind of force 4 as the ship approaced Key West the evening of the 14th seems to have been responsible for the upwelling of cooler water outside the 10-fathom line, for the temperature fell from 81.5° F. about 35 miles from the sea buoy to 79.8° F. 20 miles out, where the water is 13 fathoms deep, then rose rather evenly to 83.8 at the sea buoy and kept at this temperature to Key West. (Fig. 6.).

The thermogram of August 11–18, 1929 (Fig. 7), obtained by Mr. H. L. Kissen, chief engineer, during Mr. Stanton's vacation, shows late summer temperatures. With the sun less high in the sky and the general level of Gulf Stream temperature near its maximum, the temperatures in August are less contrasted than in early July. The same features of high Key West temperatures, warm Habana Harbor, and warmer afternoon than night temperatures are in evidence.

The thermogram of August 6 to 11, 1928 (Fig. 8), shows the flatness of cloudy disturbed weather while a hurricane is passing at a moderate distance. At the beginning of this week the storm was centered over the southern Bahamas; the 7th it was nearest Key West, being over the Gulf Stream east of Miami. The next two days the storm was traveling northwestward through Florida. Habana, appreciably farther from the storm track than was Key West, shows the ordinary high temperature prongs of the open portion of the harbor. The daily range of Gulf Stream temperature was kept small, about 0.5° F., till near the end of the week, when it increased to 1° as the hurricane drew away.

Autumn thermograms.—A hurricane that comes close enough to stir the waters vigorously as well as to spread its dense cloud canopy lowers harbor-water temperatures considerably [15] and Gulf Stream temperatures appreciably.[16] The hurricane of the end of September, 1929, passed close by Key West on the northeast, the center at its nearest point being but 30 miles away. The (5-min.) average wind velocity at Key West on September 28 reached 66 miles an hour, with gusts estimated at 80. The thermogram for September 22 to 29, 1929 (fig. 9), shows a fall of Key West Harbor temperature of 1° as the hurricans approached, then a 24-hour fall of 5° as the storm passed. While the ship was in Key West Harbor during the storm this record of the harbor temperature was obtained. After the storm a cool spot appeared in the straits about two-fifths of the way from Key West to Habana, and, with little current in the stream, stuck there for several days, moving northward and disappearing October 12. (Fig. 10.) A squally and rainy week, October 6 to 13, 1929, reduced Key West temperatures 5° and Habana's 2°. The cool spot or streak was some 5 miles wide the night of the 9th or 10th and had a temperature exactly the same as that at Key West, suggesting that this water had come from the reefs or the shallow eastern part of the Gulf of Mexico, perhaps pushing along in the faster current outside the generally quiet water immediately south of the keys, and thereby appearing as a cool streak.

Strong northerly cool winds blowing over the warm waters of the reefs and Straits bring notable changes in a short time, exceeding the cooling by a hurricane. The effect of the norther of November 20–28, 1928, has already been described.[17] The thermogram of November 18–25 (fig. 11) shows the rapid fall of Key West temperature, the less precipitate decline of Habana Harbor temperature and the rather slow cooling of the Gulf Stream as a whole. The following thermogram, November 26–Dec. 2 (fig. 12), shows the appearance of marked cool streaks in the Gulf Stream on the 7th day of the northerly wind, and the increasing invasion of cool water during the several days following. M. Idrac's observations of the yacht *Jamaica* of temperatures to depths of 1,000 meters on a line north from Habana November 24–25 and again December 1 show that the decrease in temperature was more than a surface phenomenon.[18] Between the observations of Nov. 25 at 28 miles north of Habana and those of Dec. 1 at 24 miles north of Habana, the temperature at the surface fell 0.8 deg. C., that at 200 meters fell 3.7 deg. C., that at 400 m., 2.6 deg., and that at 600, 0.7 deg.[19] In other words, at the mean position of the axis of the Gulf Stream (according to Pillsbury), the temperature of the water to a depth of a quarter of a mile fell 5° F., at a depth of nearly one-half mile the temperature fell about 1°. This does not mean that such a great mass of water lost enough heat in this short time to effect this fall in tem-

[15] I. R. Tannehill in unpublished manuscript. The cold-water trail of the hurricane, 1923, shows that in four hurricanes, 1882–1886, the sea temperature at a depth of about 12 feet in Galveston Harbor was 1° to 2° F. cooler for the 6 days after a hurricane than for the 6 days before, the fall in temperature for the storm of August, 1886, amounting to 6.4° F. from 2 days before the storm (89.1° F.) to the day of the storm (82. 7 F.). He ascribes this cooling to increased tides as well as to cloudiness, rainfall, and wind stirring. The average change between low and high tide he found was 34° F.

[16] Hazel V. Miller in abstract of paper on Temperature Variations in the Gulf Stream in the Straits of Florida, 1917–1921, *Bull. Am. Met'l. Soc.*, 1926, 7: 88, states that "Noteworthy is the depression of about 2° F. in temperature during the passage of a hurricane through the straits in September, 1919."

[17] Charles F. Brooks. A norther cools the Gulf Stream. *Bull. Am. Met'l. Soc.*, Mar., 1929, 10:70–72.

[18] P. Idrac. Sur quelques singularities du Gulf-Stream. Comptes Rendus, (Paris) Acad. Sci., Feb. 25, 1929, 188:644. Repr., without the diagrams, in Mo. Weather Rev., May, 1929, 57:206.

[19] P. Idrac. Personal communication with detailed data of the observations on which the diagrams in *Comptes Rendus* were based.

perature, but rather, as indicated above, that the north wind had driven more cooler water in the Straits.

Winter temperature profiles.—After a quiet week in which Key West temperatures came back to 77° F. and the warm portion of the Gulf Stream took possession of half the Straits (fig. 13), another norther setting in December 8 reduced the warm portion of the current to only one-fifth the width of the Straits, December 10 (fig. 14), the reduction from half the Straits (40 miles) to one-fifth (15 miles) taking place between 4 a. m. and noon that day. The warm portion recovered three-fourths of its former width (or 30 miles) the following night and all of it by the end of the week, but its temperature became nearly 1° F. lower than before. Not all such variations may be due to winds, for Pillsbury has emphasized the variations in direction from which the water enters the Straits under different tidal phases. He also ascribes the lesser thermometrical variations to "an interference of successive tidal impulses meeting the obstruction of the shore, whereby a vibratory motion is produced on the ocean's surface attenuating or concentrating the warm surface layer." [20]

Whether such rapid changes take place in the position of the warmer portion of the Gulf Stream off our Middle and North Atlantic seaboard is still to be determined from a study of the temperature profiles already at hand. Cursory inspection, however, coupled with years of bucket observations, indicate that changes in the position of the Gulf Stream amounting to more than 50 or 100 miles do not occur, and that such small shifts can not in anywise be considered as a "change in the course of the Gulf Stream" so commonly imagined by those who would ascribe any extraordinary weather phenomenon to such a hypothecated departure of this great ocean stream from its established position.

After further north winds at Christmas time the northern half of the Straits reached its lowest temperatures, averaging 73° F., and, in a cool streak, between the northern portion and the warmer southern, running down to 70.6° F. December 27. (Fig. 15.) Such cool streaks may be due to masses of cool water from the reefs, or to upwelling between currents of different speeds, the southern, presumably the stronger and, therefore, deflected more to the right, and away from the northern in its eastward movement. But, Mr. Stanton notes that there was practically no current this week, the southbound logged mileages averaging only 3 miles more than the northbound, when ordinarily there is a difference of 10 or 15. The persistence of the temperature profile practically unchanged in even the details of its shape was probably due to the ship passing through much the same water day after day.

The week of January 6 to 12, 1929 (fig. 16), provides good samples of winter temperature profiles, which are, in several respects, the reverse of the summer. The shallow waters of Key West Harbor and shoals are decidedly cool, while Habana Harbor is somewhat cooler than the Gulf Stream temperatures. The Straits are now coolest on the northern edge, while in summer they were warmest there. The temperatures of the Gulf of Mexico, the waters from which flow more into the northern portion of the Gulf Stream [21] are higher in summer and lower in winter than the Caribbean waters that generally feed the southern part of the Stream,[22] whereas some apparently detached warm bodies or narrow currents of water were noted near Key West on the summer thermograms (July 1 and 2), cool streaks appear in the winter in the same vicinity, most prominently January 6–9, possibly detached masses of the cooler shoal water of the western keys. Just as the detached warm bodies were not so warm as the Key West Harbor, which represents the shoal water temperature, so these detached cool bodies are not so cool as the harbor water.

Winter profiles, 1929–30, were strikingly like those of 1928–29, just described. In the week ending December 1 (fig. 17) and till December 4 the temperature of the northern quarter of the Straits was generally 77 to 78, while the southern three-quarters was as high as 81° F. In a strong northwesterly wind from December 3 to 5, the Key West Harbor temperatures dropped from 75 to 68, the north portion of the Straits from 77 to 75, and the warm three-quarters of the Straits from 81 to 79.5 and, by the 6th, to 79. Habana Harbor cooled from 80 to 76. Southerly winds at the end of the week raised the temperature of the warmer portion of the Straits to 80, where it stayed till the 11th. A slow fall ensued. Then, on the 19th, a strong cool NW. wind (maximum velocity 32 miles per hour at Key West) again drove temperatures downward. The morning after this blow, three deep nicks, showing water 2° to 4° cooler than on either side of each nick, appeared in the temperature profile of the northern half of the Straits.

After a brief respite, the following week, December 22 to 29 (fig. 18), was noteworthy for its unusually cold northerly wind. The mean daily air temperatures December 24 to 26 were 58, 60, and 59° F., or 11 degrees under the December normal. Key West Harbor sea temperature fell from 69, on the 23d, to 60, on the 26th. The cool portion of the Straits (at that time the northern two-fifths) fell from 75 to 73. The warm section was but little affected, falling from 79 to 78.5. Habana Harbor cooled from 76 to 73.5. The thermogram of this cool week looks very much like that of December 23–29, 1928 (fig. 15). The lowest temperature, at or near Key West Sea Buoy, was 58.5° F. at 11 p. m. December 25. This was 3° under the minimum of the winter of 1928–29.

With the return of normal mild weather with moderate to brisk NE. to E. winds, the cool portion of the Straits became very much restricted, in the week of January 5 to 11 (fig. 19 almost a replica of fig. 16, January 6–12, 1929). On the night of the 10th to 11th, however, as the wind backed to N. with the approach of a subtropical Atlantic low from the east, a marked cool streak made a temporary appearance in the northern portion. Its lowest temperature, 72.4, was in marked contrast with the 76.6 and 77.6 on either side. With the wind again in the NE., on the daytime return trip the 11th, the cool streak had disappeared except for a small nick in the thermogram. On the following trip, the 13th (fig. 20), as the center of the low was passing through the Straits, with brisk shifting SW. to SE. winds, a wide segment of cool water, about 20 miles wide appeared between warmer water near the north portion of the Straits and the warm water in the middle. The minimum temperature of 71.5 was sandwiched between maxima of 77.1 and 77.6. After disturbed weather—two days with southerly winds and two with NW. to N. the next trip, on the 17th, revealed the more usual winter time cool water in the northern quarter, and warm in the southern three-quarters. Warmer water had recaptured part of the Straits previously occupied by cooler.

In the more settled moderate weather of January 20–26 (fig. 21) the thermogram was very much like those of spring. On some days as much as 1° diurnal range of temperature appeared. With further wintry weather,

[20] Pillsbury, op. cit., p. 506.
[21] Ibid., p. 609.
[22] H. V. Miller, loc. cit., p. 87.

however the following thermogram resumed a strongly contrasted appearance. The rather quiet week of February 2–9 (fig. 4) had rising harbor and Gulf Stream temperatures till the 7th, after which a cool wind drove temperatures down again. On the warmest days, February 5 and 6, an appreciable diurnal range again appeared.

Spring profiles.—The week of March 3 to 10, 1929 (fig. 22), while showing a cooler northern half of the Gulf Stream than some winter profiles, already began to exhibit the warm shoal-water spires of summer. In the earlier part of the week, Key West and Habana temperatures were, as in summer, above those of the Gulf Stream. But a strong northwest wind the 5th and 6th depressed Key West Harbor temperatures 6° and Habana 2°. At the same time, the cool-water portion of the Gulf Stream was widened at the expense of the warm, owing, apparently, to a greater contribution of water from the Gulf of Mexico.

In the week of May 12 to 19, 1929 (fig. 23), the relative coolness of the northern portion was still in evidence. It was scarcely less marked, however, than the cool water on the Cuban side. The stream was warmest in the middle. As the notations on the thermogram indicate, this was a windy week, with east and southeast winds of force 3 and 4, and with a sea that kept the ship rolling considerably. Thus, it is not surprising to find rather smooth profiles and no more than 0.5° F. daily range of temperature. In spite of the wind, however, Key West Harbor temperatures continued a degree or two above those of the Gulf Stream. With the quieter conditions of the following week (fig. 24), Key West temperatures shot up 2°, and the surface of the Gulf Stream rose 1°, while daily ranges increased to 2° or 3°. The highest temperatures, May 22 and 23, occurred between 2:30 and 4:00 p. m.

Five temperature, density, and salinity profiles run across the Gulf Stream between Key West and Habana and between Miami and Nassau by the writer, in April, 1929, brought out the following facts: (1) Reef and bank water was the most saline; (2) southeast Gulf of Mexico and Cuban shore water was the least saline; (3) cool streaks (?) in the left half of the Gulf Stream were the most saline parts of the stream, though less saline than the waters of the Florida keys or Bahama banks. It seems likely that the cool streaks at this time were made up of water upwelling from the more saline layer which is not far below the surface in the left portion of the Gulf Stream. In view of the lower salinity of the southeastern Gulf of Mexico, it is evident that these cool streaks could probably have had no immediate relation with the water of the southeastern Gulf north of Key West. This southeastern Gulf water, furthermore, was cooler than the lowest temperatures found in the Gulf Stream south of Key West.[23]

A detailed discussion of these observations, which included 174 with a hydrometer, and a collection of 64 samples which were later titrated at Harvard, through the kindness of Dr. Henry B. Bigelow, will be presented in a separate paper elsewhere.

CONCLUSION

The surface waters of the Gulf Stream in the Straits of Florida are diverse in temperature and are subject to considerable variations from day to day. Much of the interdiurnal variation is closely related to the weather, especially the wind, which disturbs the surface. Characteristic differences in the general shape of the surface temperature profile across the Straits seem to arise from the frequent occurrence of cool northerly winds in winter, reducing the surface temperatures on the Key West side, and from the prevalence of warm southeasterly winds in summer which raise the temperatures there. There are, however, certain fundamental differences in temperature which can not be related to the immediate weather. These will be discussed in another paper, to follow this one immediately. The thermograms have all been tabulated in detail, and weekly means have been derived for publication.

[23] Charles F. Brooks, Surface Temperature, Density, and Salinity profiles across the Straits of Florida. Bull. of the National Research Council, 1930.

INTERNATIONAL METEOROLOGICAL ORGANIZATION

ARTICLE I

The present International Meteorological Organization, created at Utrecht in 1878,[1] revised at Paris in 1919, at Utrecht in 1923, and at Copenhagen in 1929, comprises:

1. The conferences of the directors.
2. The International Meteorological Committee.
3. The secretariat of the organization.
4. The commissions of the organization.

ARTICLE II

1. The conferences of the directors have for their principal function the discussion of administrative questions and the means of execution, in order to put themselves in accord on the methods of observation and of calculation, to decide on the common work that ought to be undertaken, and to create eventually the necessary commissions; purely theoretical questions are not in the jurisdiction of the conferences.

2. The conferences are composed of the directors of the independent national meteorological networks of all nations.

3. The conferences are convoked by the International Meterological Committee; they ought to take place at least every six years. They ought also to be convoked extraordinarily by the committee when urgent questions arise for its consideration. Convocation is obligatory when it is called for by a quarter of the members of the conference.

4. The president of the committee gives notice of the meeting by circular a year in advance to the members of the conference (and the presidents of the commissions) and causes to be designated by a vote of the committee the date and the precise place of the meeting.

5. The president of the international committee convokes directly all the members to the conferences; the secretariat establishes the list and publishes it each year after having brought it up to date.

6. The members of the conference have the right to have themselves represented if they are not able personally to take part in the conference. The substitutes ought to belong to the service represented or to be a part director of the service; he should not be a member of the conference under another title.

7. The decisions are taken by a majority of the voices of the members present, save in case a vote by countries [2] is demanded, even by a single member.

8. The conference of the directors names the International Meteorological Committee, the powers of which end at the ordinary conference following.

9. The conference chooses its president, who rules over its functions during the entire duration of the session.

ARTICLE III

INTERNATIONAL METEOROLOGICAL COMMITTEE

1. The members of the committee ought to belong to different countries and be members of the conference.

[1] So definite a statement as this must have been based on grounds not available on this side of the Atlantic; nevertheless, whatever, may have been in the minds of the directors in attendance on the Utrecht meeting of 1878, no mention is made in the proceedings of that meeting of the creation of an International Meteorological Organization. The report of the Berne meeting of 1880 bears the title "Report of the International Meteorological Committee" and thus it became the habit of some, at least, to think of the organization as a whole as that known by the title just mentioned. In commenting upon the statutes of the International Meteorological Organization, immediately following this article, the present writer adopts the view that the title, "International Meteorological Organization," was first broached at the Paris meeting of 1907, and approved at the Paris meeting of 1919.—*A. J. H.*

[2] One understands by this word all countries that govern themselves. (Example Dominion of Canada.)

2. The number of the members of the committee is fixed by the conference of the directors.

3. The committee has the right to replace a decedent or resigned member.

4. When a member of the committee ceases to be director, he is continued on the committee until the next meeting of the committee.

5. The committee may add to itself in a consultative title such persons whose counsel appears useful to it.

6. The committee names an executive council composed of the president and four other members chosen from itself. Interior regulation, approved by the committee, rules the functions of the executive council.

7. The committee supervises the execution of the decisions of the conferences in the interval between meetings; it receives and should approve the reports of the commissions; it takes all necessary measures for the development of international meteorology.

8. The president of the committee is elected by the committee and has charge of its functions until the next ordinary session of the conference.

9. The retiring president, in case he has been elected for more than four years, is not immediately eligible. This clause is applicable only after 1935.

ARTICLE IV

THE SECRETARIAT OF THE INTERNATIONAL METEOROLOGICAL ORGANIZATION

1. The secretariat, functioning under the direction of the president of the International Meteorological Committee, is charged with the organization of the meetings of the conference, of the committee, and of the commissions, as well as of the publication of the minutes. It constitutes, likewise, a center of documentation relative to the meteorological services of the entire world, and it assists, to the extent of its means, the president of the committee and the presidents of the commissions in the execution of their work.

2. The expenses of the secretariat are covered by the optional subventions of the different national services in the proportion of 4,000 gold francs for a large State, 2,000 gold francs for a medium sized State, 1,000 gold francs, or a lesser sum, for other States.

3. The executive council of the committee manages the budget of the secretariat, the compatibility of which is communicated each year to members of the conference.

4. The definite seat of the secretariat is fixed in Switzerland.

5. The composition of the secretariat and the assignments of its personnel are fixed by the executive council of the committee.

ARTICLE V

COMMISSIONS

1. The commissions, instituted by the conference or by the committee, ought to include at least one member of the committee. In the newly created commissions the first president is nominated by the conference or by the committee.

2. Once constituted, the commissions have the faculty of completing themselves and of organizing their work at their will.

3. The presidents of the commissions, who are not members of the committee, are invited to assist in the sessions of the latter and to take part in the discussions with a consultative voice. The presidents furnish, at the beginning of each session of the committee or of the conference, a report on the work of their commissions.

4. The commissions meet at least once every three years. The designation of the place and of the date of the meetings is made after preliminary consultation between the president of the committee and that of the commission. The decisions are taken by the majority of votes of the members present, save in the case where the vote by countries is demanded.

5. Those persons who wish to propose a question for the deliberation of the conference, of the committee, or of a commission, ought first to request the interested presidents that this question be placed on the order of the day, and to send, not later than two months before the meeting, a short summary of this question to the secretariat, who will distribute copies of it to members of the conference who express the desire, to members of the committee or of the commissions interested.—*Translated from the French by Margaret and Charles F. Brooks.*

REMARKS ON THE FOREGOING

Meteorologists on this side of the Atlantic have been more or less confused by references to the International Meteorological *Organization*, a title evidently used to indicate the body best known in this country as the International Meteorological *Committee*. For the benefit of our readers the following outline history of the successive steps taken in the main by Europeans to standardize meteorological methods and practices since the beginning of activity in that matter is presented.

The history readily divides itself into two periods the first of which came to a close with the World War and the second, or present, having its inception at the Paris, 1919, conference of directors.

The first or original meeting of meteorologists was held at Leipzig in 1872, in pursuance to a call issued by Messrs. Wild, Bruhns, and Jelinek, directors of meteorological services at St. Petersburg, Leipzig, and Vienna, respectively. There were 52 persons in attendance at this conference which continued for three days, during which many practical questions were discussed and arrangements were made for the first meteorological congress to be held in Vienna in 1873. A permanent committee of seven members was elected at Leipzig, which functioned as a sort of executive committee for many years.

The Vienna congress did not create a formal organization or enact by-laws for the government of its sessions. It did, however, create a number of subcommittees for the consideration of sundry questions that came before the congress; these subcommittees were later changed to "commissions" with a more or less permanent form of organization.

A conference was held in Munich in 1891, Paris in 1896, Innsbruck in 1905, and the next one was scheduled for 1914, but by reason of the World War was not held, and with the close of the war came also the temporary end of all international agreements.

The International Meteorological Committee is first mentioned in nonofficial document No. 14 printed by authority of the Meteorological Council of Great Britain in 1881, under the title "Report of the International Committee Meeting at Berne 1880." In that report it is stated that the first meeting of the committee was held in Rome on April 22, 1879. There were present at this meeting Messrs. Cantoni, Capello, Hann, Mascart, Mohn, Neumayer, Scott, and Wild. The last named was elected president of the committee and Scott was elected secretary. This committee which in the earlier years of its existence was charged with carrying out the recommendations of the congresses, making arrangements for the conferences of directors, etc., seems never to have clearly formulated its sphere of action until the meeting of the committee held in Paris in 1907 when M. Mascart the retiring president prepared a statement of the regulations that had been acted upon in practice since 1879. Before the règlement could be acted upon the war broke out and approval was not obtained until 1919. In that year the directors of the meteorological services of Great Britain, France, and Italy, after an exchange of views, agreed to summon an international conference of directors in Paris in September, 1919. At this meeting the organization proposed in 1907 was approved. Doubtless an added reason for its approval was the creation of an international union of geodesy and geophysics in which sections devoted to meteorology and terrestrial magnetism and electricity were included. Both of these subjects had been embraced by the international body of meteorologists and magneticians.

It was at the Paris meeting of 1907 that the name *International Meteorological Organization*[3] was first defined as consisting of—

1. Conference of directors.
2. The International Meteorological Committee.
3. Commissions.

The International Meteorological Committee continues to function, as in the past, as the executive committee of the conference of directors the body as a whole being known as the International Meteorological Organization.—*A. J. H.*

[3] Subsequent changes were the addition of a secretariat as shown in the beginning of this article.

THE INTERNATIONAL CONVENTION FOR SAFETY OF LIFE AT SEA, LONDON, 1929

By E. B. CALVERT,[1] Chief of Forecast Division

[Weather Bureau, Washington, May, 1930]

There were two international conventions held in 1929 which resulted in agreements of high importance to meteorology. The first of these, the International Convention on Safety of Life at Sea, was held in London from April 16 to May 31. On the latter date it was signed by the delegates of the 18 maritime nations that were represented. No nation failed to sign. In all there were 172 officially appointed delegates and experts, and a considerable number of advisors not included in the delegations. These statistics are mentioned merely to indicate the magnitude of the assembly and its importance. It was the second international conference of its kind, the first having been held in 1914 as a result of the *Titantic* disaster.

Meteorology had small part in that first conference in 1914. Scarcely could it be said that "it was among those present." As a matter of fact, so far as can be ascertained, no meteorologist was in any national delegation. Nevertheless, it must have been recognized that weather is a menace to safety of navigation with which ships must contend because several pages of the convention as signed were devoted to meteorology but in a form that placed no obligation on ship masters to furnish weather reports. It consisted of codes, tables, and generalizations which were of no use to anybody and in fact were obsolete by the time the convention articles were published.

Meteorology had a far different status in the 1929 convention. This was due in considerable part to the International Meteorological Committee, aided in some degree, no doubt by the strong recommendation of the Chief of the United States Weather Bureau that a meteorologist be included in the United States' delegation. At meetings of the subcommittee on synoptic weather information held in London in June, 1928, a resolution was adopted urging representation of the International Meteorological Organization in the convention and naming the president of the International Meteorological Committee as its representative. This resolution was brought to the attention of the British Government which called the convention and controlled official procedures. The resolution also came to the attention of the officials of the various governments invited to participate in the convention. The position of the British Government was in effect that it could not recognize unofficial organizations but that any government was at liberty to compose its delegation to represent any phase of safety of life at sea it might desire; also, that during the convention advisors outside of the official delegations could be utilized. Three nations had meteorologists in their delegations—Great Britain, Germany, and the United States.

As is customary in international conferences, committees were formed to handle different subjects. The committee on safety of navigation was one of the five major committees thus formed. The major committees in turn appoint subcommittees. Meteorology came within the scope of the committee on safety of navigation and was the first subcommittee to be formed. Each nation had the privilege of naming a member. It was expected that the subcommittee would be small but the actual number was 19, representing Italy, England, France, United States, India, Australia, Germany, Russia, Netherlands, Norway, Denmark, Canada, and Japan. The subcommittee was augmented by Colonel Gold, of the British Meteorological Service, and Captain Bureau of the French service by special designations of the chairman of the delegations of their respective governments. These facts are mentioned to indicate the recognition given to meteorology in the 1929 convention in contrast with the convention of 1914.

As might be expected, many viewpoints were advanced by the membership of the subcommittee, all of which required patient discussion and adjustment, but in basic principles there were few divergencies of opinion. Details of the discussions and descriptions of the proposals that were rejected, modified, or accepted, are interesting but it is not practicable to discuss them within the limits of this program.

The committee on navigation accepted the report of the subcommittee with no material modification and by a large majority vote, but strong objection was offered by the Danish delegation to the article which stipulated that instructions to ships concerning meteorological observations should be given by the national meteorological service of the country under whose registry the ships are operating. This clause was lengthily debated and the subcommittee's report was approved with only three negative votes. However, the Danish delegation carried their point in the plenary session.

The 1929 convention as signed is divided into two parts. The first consists of covenant or convention articles and the secod of regulations governing procedures in application of the convention provisions. In the 1914 convention meteorology was not mentioned in the convention articles and therefore it had no legal standing. Inconsequential paragraphs pertaining to weather, which were so worded as to place no obligations on anybody, appeared solely in the regulations.

The meteorological subcommittee at London drafted two convention articles, one dealing with obligatory reports to be made by all shipmasters, the second enjoining governments to encourage certain meteorological arrangements of importance to safe navigation. They are, respectively, articles 34 and 35 of the convention.

Article 34 enumerates certain dangers to navigation, which masters are compelled to report under penalty. Dangerous ice, derelicts, and "dangerous tropical storms" are specified. On the other hand, it places obligation on each administration to take all steps it considers necessary to insure that the dangers when reported be promptly

[1] Presented before the American Meteorological Society, Washington, 1930.

brought to the knowledge of those concerned and communicated to other administrations interested. This article reads as follows:

ART. 34. The master of every ship which meets with dangerous ice, a dangerous derelict, a dangerous tropical storm or any other direct danger to navigation is bound to communicate the information, by all the means of communication at his disposal, to the ships in the vicinity, and also to the competent authorities at the first point of the coast with which he can communicate. It is desirable that the said information be sent in the manner set out in Regulation XLVI.

Each administration will take all steps which it thinks necessary to ensure that when intelligence of any of the dangers specified in the previous paragraph is received, it will be promptly brought to the knowledge of those concerned and communicated to other administrations interested.

The transmission of messages respecting the dangers specified is free of cost to the ships concerned.

The scope of article 35, as previously indicated, involves moral responsibility and cooperation, rather than compulsion. It is comprehensive and self-explanatory:

ART. 35. The contracting governments undertake to encourage the collection of meteorological data by ships at sea, and to arrange for their examination, dissemination, and exchange in the manner most suitable for the purpose of aiding navigation.

In particular, the contracting governments undertake to cooperate in carrying out, as far as practicable, the following meteorological arrangements:

(*a*) To warn ships of gales, storms, and tropical storms, both by the issue of wireless messages and by the display of appropriate signals at coastal points.

(*b*) To issue daily, by radio, weather bulletins suitable for shipping, containing data of existing weather conditions and forecasts.

(*c*) To arrange for certain selected ships to take meteorological observations at specified hours, and to transmit such observations by wireless telegraphy for the benefit of other ships and of the various official meteorological services, and to provide coast stations for the reception of the messages transmitted; and

(*d*) To encourage all shipmasters to inform surrounding ships whenever they experience wind force of 10 or above on the Beaufort scale (force 8 or above on the decimal scale).

The information provided for in paragraphs (*a*) and (*b*) of this article will be furnished in form for transmission in accordance with article 31, paragraphs 1, 3, and 5, and article 19, paragraph 25, of the general regulations annexed to the International Radiotelegraph Convention, Washington, 1927, and during transmission "to all stations" of meteorological information, forecasts and warnings, all ship stations must conform to the provisions of article 31, paragraph 2, of those general regulations.

Weather observations from ships addressed to national meteorological services will be transmitted with the priority specified in article 3, additional regulations, International Radiotelegraph Convention, Washington, 1927.

Forecasts, warnings, synoptic and other meteorological reports intended for ships shall be issued and disseminated by the national service in the best position to serve various zones and areas, in accordance with mutual arrangements made by the countries concerned.

Every endeavor will be made to obtain a uniform procedure in regard to the international meteorological services specified in this article, and, as far as is practicable, to conform to the recommendations made by the International Meteorological Organization, to which organization the contracting Governments may refer for study and advice any meteorological questions which may arise in carrying out the present convention.

The regulations article in the 1914 convention was discarded by the subcommittee because it was long, complex, impracticable, and had never been brought into general use. The new regulation (Regulation XLVI) prepared by the subcommittee was adopted as presented. It deals entirely with details of procedure on the part of shipmasters in reporting "dangerous tropical storms," and other dangers to navigation, as required by article 34. It is as simple and as short as possible consistent with supplying instructions which will enable shipmasters to prepare in a uniform manner the dangers which they are compelled to report.

The complete convention, in English and in French, has been published by the Department of State and may be obtained by purchase from the Superintendent of Documents, Washington, D. C.

At this time (May 1, 1930), the convention has been formally adopted by a considerable number of the participating governments. It has not yet been considered or ratified by the United States Senate.

The significance and importance of the London convention will appeal at once to meteorologists. It was epochal. Undoubtedly it will be of incalculable benefit to the future standing and progress of meteorology. For the first time this science and service was given recognition in an international agreement; for the first time official recognition was given by governments to the International Meteorological Organization. The convention has advanced the influence and standing of that organization to a position which will make it a potent factor in strengthening and stabilizing working arrangements among the national meteorological services of the world. In this connection it is pertinent to remark that for many years prior to the London convention there was no lack of cordial cooperation and understanding between the meteorologists of the world, even during periods of stress and national enmities caused by war. There has never been any need for peace conferences among national meteorological services; but there has been and always will be necessity for frequent meetings to work out uniform methods of procedure and adjustments of service.

The second conference of prime importance to meteorologists was the sexennial meeting of the International Meteorological Organization held in Copenhagen, Denmark, in September, 1929. Prior to its sessions the various commissions of the organization were held in the same city. Incidentally it may be mentioned that during the summer the British Government had called together in London all of the directors of the meteorological services in its dominions. Although this conference was British in its scope, and its accomplishments not of direct concern to other nations, it had important bearings on the Copenhagen meetings because most of the attendants also went to Copenhagen and participated in the meeting of the commissions and the organization.

INTERNATIONAL METEOROLOGICAL ORGANIZATION, COPENHAGEN, 1929

The International Meteorological Organization meeting at Copenhagen was the most representative one ever held. Never before had so many of the workers in meteorological science come together. Thirty-four countries were represented and about 40 independent services, the number of delegates, commission members, and allied participants being 93. Germany had 16, England, Sweden, and Norway had 5 each, Japan and Spain 4 each, while the other countries were represented by from 1 to 3 each.

The International Meteorological Organization is not exclusively meteorological in character. It embraces other subjects such as terrestrial magnetism, atmospheric electricity, hydrology, etc. All of the commissions, 12 in number, held meetings during the week preceding the session of the parent organization. The sessions of the latter in the main were devoted to consideration of the reports of the commissions. The International Meteorological Organization meets every six years, but many of the commissions meet more frequently so that all of their actions and resolutions during the 6-year period since the conference held in Utrecht in 1923 required action.

Discussion, even in abstract, of the proceedings at Copenhagen would require more space than is practicable here. A full report will be published and become available to those interested in the whole proceedings or special portions thereof. Therefore, remarks will be confined to a few outstanding accomplishments.

For many years there has been general recognition of the necessity for organizing ship reporting service on a uniform basis. Every maritime nation has been proceeding along lines of individual organization, employing codes of its own, securing data according to its own ideas of necessity, and arranging for collections best adapted to its own communication facilities. The problem of international coordination of ocean service was discussed at subcommission meetings held in Paris and London in 1928. These meetings were attended by the Chief of the Weather Bureau and the Chief of the Forecast Division. The conclusions reached, in the form of 12 resolutions, were adopted without material change at Copenhagen. These resolutions, in substance, provide—

That each nation shall arrange with a certain number of selected ships to take standard observations regularly, the number of selected ships to be equitably distributed among the nations according to tonnage.

That the standard hours of selected ship observations shall be 0000, 0500, 1200, and 1800 G. M. T., and that when only two observations a day are transmitted the preferred hours will be 0000 and 1200.

That adequate facilities be provided for exchange of ship observations among the meteorological services requiring them.

That a universal code be employed.

That, pending international agreements regarding nonselected ships, no restrictions will be placed on any country in providing service from such ships to meet domestic requirements or in the transmission of reports therefrom in either plain language or in any published code.

NOTE.—This provision was designed to prevent interference with service such as the United States has in connection with its hurricane warning work.

That encouragement be given to the establishing at the Azores of a collecting center for ship reports in the North Atlantic and for forecasting service.

NOTE.—The Portugal Government already has erected a radio station at the Azores and has begun collecting ship observations.

That all arrangements relating to ships and ship observers shall be a national procedure through the meteorological institute of the country under whose registry the ships are operated.

Concerning the foregoing, it may be said that the United States Weather Bureau already has begun its selected ship program, that 20 selected ships of United States registry are reporting regularly; and that on May 1, it put into use on such ships the universal number code as adopted at Copenhagen. A detail of this program is that selected ships, regardless of nationality, in the North Atlantic will radio their reports to Washington when west of longitude 35°, and to the Azores or some other selected European station when east of 35° longitude. Already 20 United States ships, 32 British ships, and 5 French ships are radioing their observations to Washington. It is expected that in a few months 10 German ships will come into the program. All of these messages are included in the bulletins that are transmitted twice daily (11 a. m. and p. m.) from the Weather Bureau, through Navy radio station NAA, for the benefit of the European meteorologists. However, arrangements for United States ships to transmit reports to Europe when east of 35° longitude, have not been completed due to some pending questions pertaining to radio tolls.

An outstanding accomplishment at Copenhagen was the agreement reached pertaining to international codes. This is a matter with which national services struggled for many years. The problem had many difficult angles, some of them appearing to be impossible of adjustment. Every nation has its peculiar situations of public service which require that data be supplied in certain forms of substance and arrangement. This problem was particularly acute among European countries because of their relatively small geographic areas, their dependence on each other for observations, and the necessity for coordination of communication arrangements so that weather reports could be made quickly available without sacrificing data that each desired. Transmission in code is necessary, because plain language would produce a volume that would choke communication facilities. A number code in groups of 5 is best for the purpose. It is believed that now this opinion is universal.

Securing agreement as to form of the codes and of the data to be universally utilized was not so simple. For instance, some were satisfied with a few cloud types, others wished a hundred. The requirements of some were satisfied in expressing state of weather in a few terms, such as clear, cloudy, raining, snowing, etc., while others insisted on divisions of a hundred parts. Similar complications and viewpoints were numerous. Other technicalities involved arrangements of the data in the number groups and the arrangement of the groups in the messages. This perplexing problem came within the purview of the commission on synoptic weather information, of which Col. E. Gold, of the British Meteorological Service, has been president for many years. It was due in large part to his skill and tact that the code question was amicably settled at Copenhagen. Forty-eight symbols, subject to a few modifications, and 22 data tables applicable to the code symbols and arrangements were adopted. This year for the first time in the history of international meteorological relationships a common code for use in international work will come into use. It stands out as one of the great accomplishments at Copenhagen. No longer will a ship captain be required to consult a volume of hundreds of pages in his efforts to decode a weather report handed to him by his radio operator. No longer will an airship circumnavigating the world, as did the *Graf Zeppelin*, have to carry over 30 weather-code books in order to prepare weather charts. Hereafter, one code book will suffice and not be a very large one at that. Every figure in the code will have a precise meaning and the same meaning regardless of the ship or country from which an observation emanates.

Another important decision related to units to be used in expressing barometric pressure. Inches and millimeters gave way to millibars. In the future millibars will be used in all international transmissions. Temperature did not fare so well. No universal unit was adopted. Centigrade and Fahrenheit scales will continue in use according to national preferences.

Another important accomplishment related to international collecting and distributing weather reports. The conference remarked that five great wireless transmissions of a character pecularily international are required under present conditions for synoptic meteorology of the Northern Hemisphere, and that there are five nations in a specially favorable position for the collection of the information required and their transmission to meet international requirements. They are: France for Western Europe; Germany for Central Europe; Russia for European and Asian areas under Russian control; England for collective transmission to America of reports from the eastern Atlantic and Europe; and United States for collective transmission to Europe of reports from the western Atlantic and North America.

The conference expressed the hope that the meteorological services of these five countries would be able to undertake the services mentioned in the interest of meteorology in the Northern Hemisphere.

For several years past the United States Weather Bureau has been doing what was allocated to this country in the form of the so-called Angot broadcasts at 11 a. m. and p. m., E. S. T. Therefore, no material change in its program will be necessary. France has been transmitting for the benefit of services on this side of the Atlantic a bulletin (once daily) containing European reports. When the suggestions of the conference are complied with, England will take over the duty of transmitting European reports to America, relieving France of the obligation. These arrangements are now under way and it is expected that they will be put into effect within a few months.

In all, there were 109 resolutions adopted at the Copenhagen conference, covering a wide range of activities. All are important, but it has been practicable to refer only to a few which appear to have the most direct bearing on our own activities.

The by-laws or operating rules of the International Meteorological Organization were changed in several important respects. Some of the principal changes are:

Provision for a permanent secretary whose salary will be paid from contributions by the various services.

Provision whereby a director who is unable to attend a called meeting of directors may name a representative, but such representative must be an official of the service that he represents or else a former director thereof.

Location of the permanent headquarters of the secretary in Switzerland after the ensuring 6 years, the office to remain in Holland until that time.

The creation of an executive council of 5 to handle administrative details of the organization in place of the former cumbersome method of referring questions to the International Meteorological Committee (about 20 members) scattered in all parts of the world. The executive council appoints the personnel of the Secretariat and controls its budget and activities. The Chief of the United States Weather Bureau has been elected a member of this council.

NOTES, ABSTRACTS, AND REVIEWS

Weather forecasting from Synoptic Charts by Alfred J. Henry.—The present is the second in the series of Weather Bureau publications on this subject. The first one, Weather Forecasting in the United States, issued in 1916, is out of print. The method of treatment in the present work differs somewhat from that followed in the first of the series. The subject, as every one knows, is difficult of treatment because of the limitations in size and the number of the charts that may be reproduced. The first work contained about 160 charts, the second has but 23 but with these last-named are presented the daily forecasts for each State in the Union together with a statement of the guiding principle, or principles, in mind in each case. No doubt the average reader would like to have had these principles developed at greater length, but to have done so would have made the publication interminably long and wearisome in the reading. The aim has been to give just enough of a suggestion for the groundwork of the forecast to excite the curiosity of the reader for more, in the belief that it is only by intensive study of the problem that a clear understanding will be reached.

There is included in the publication a brief history of the beginnings of weather forecasting in this country, thus filling a gap in the history of the Federal Weather Service that would be difficult to supply in future years.

The publication the full title of which is Miscellaneous Publication No. 71, U. S. Dept. Agri., can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the price of 20 cents the copy.—*A. J. H.*

P. R. Gast on a Thermoelectric Radiometer for Silvical Research,[1] *review by H. H. Kimball.*—The author lays down the following requirements:

1. It should be sensitive to radiation between the limits λ 0.29μ to 2.5μ, which embraces practically the entire wave-length range of energy received at the surface of the earth from the sun.

2. It should be capable of measuring radiation intensitives over the wide range from the lowest intensities in the forest to full sunlight.

3. The sensitivity must be inherent in the instrument, which must be fully and equally sensitive to rays coming from all directions, or it must be possible to amplify the registration.

4. It must be nonselective for different wave lengths.

5. The readings of the instrument must be capable of being expressed in terms of fundamental units of measure, such as gram-calories per unit of area and time.

6. It must be possible to use the radiometer with a recorder of simple and rugged construction.

After trying out 11 devices using different types of receivers and methods of temperature measurements, it was decided to use the nonselective heating method and to register the temperature changes by means of thermoelectric effects. The spherical hot-junction thermopile was found best adapted to the requirements specified in paragraphs 1 to 6, above.

In the illustrations of this thermopile, given in the paper, there are five spherical hot junctions consisting of nickel-silver beads 0.1 inch in diameter to which constantan and iron wires are spot welded. The cold junctions are disks of pure nickel 0.2 inch in diameter and 0.02 inch thick to which the thermocouple wires are also spot welded. The cold junctions are shielded by mounting them between annular shields of mica, which are blackened on their inner surfaces but bright (or white) on their outer surfaces. The hot junctions are coated with lampblack. The thermopile is then mounted on the stem of an electric lamp, baked in an electric oven, and sealed in an evacuated electric-lamp bulb. Thus mounted the iron wire does not rust, and the durability and sensitiveness of the thermopile is greatly increased.

It was customary in field work to connect three of these thermopiles in series at each point where measurements were desired and connect them with a recording galvanometer capable of recording the indications for four different points or stations on one record sheet.

Discussing the thermopile data for the year 1925, the author remarks:

> In the first place it may be noted that the maximum total daily values are obtained in July and August. This is not in accord with the calculations of Kimball (1919) whose data indicate the probability of maxima in May and June. The explanation of the difference is apparently due to Kimball's use of vapor pressure

[1] A Thermoelectric Radiometer for Silvical Research, by P. R. Gast. Harvard Forest Bull. No. 14. 76 pp. 25 figs. Harvard Forest, Petersham, Mass. 1930.

and not relative humidity in determining the probable transmission of the atmosphere. The use of vapor pressure as a criterion predicts the probability of clear skies; the use of relative humidity predicts the probable duration of cloudy weather and the probable radiation absorption in the clouds. A study of the data presented by Piipo (1928) confirms this analysis.

If the author will consult graphs in Figures 1 and 2, pages 157 and 158, MONTHLY WEATHER REVIEW, April, 1927, which are based on records by automatic instruments at widely scattered stations, I think he will be convinced that as a rule the maximum daily totals of solar radiation received on a horizontal surface in the open occur in June. This is a rule to which there are exceptions, and does not necessarily apply to measurements made with the spherical hot-junction pyrheliometer under the forest canopy.

The results of this important study are summarized in the author's conclusions which follow:

It appears that there has been a sound physical reason for empirical attempts to develop scales of tolerance. While "light" has for many years been stressed as the important factor in silvicultural operations, looking to the regeneration of the forest, the recent decade has seen the pendulum swing far in the other direction. Foresters in the United States have tended to minimize the importance of radiation.

This tendency was doubtless because most of the intensive fundamental research has been in regions where the small yearly precipitation or the low summer rainfall pointed to available soil moisture as the limiting factor (Bates and Zon, 1922).

But where rainfall is well distributed and on the less meager soils in New England, it is possible to overemphasize the importance of soil moisture in the growth and development of trees. Several years' observations with an apparatus which gives a truer record of the total radiation than any previously used show that over and above the deviations in growth which are due to seasonal water supply the relation of growth to total radiant energy remains constant and conspicuous.

Therefore the attempt to develop successful methods of controlling natural reproduction must continue primarily to consider the reaction of germination, growth, and development to the total radiation that reaches the forest floor.

Dr. Felix M. Exner, 1876–1930.—In the peaceful passing of Doctor Exner on the morning of February 7 there was lost to meteorology one of its most distinguished investigators, to German meteorologists a highly honored colleague, and to a narrower circle a most sincere friend. Intimate friends had sorrowful knowledge that a physical ailment was slowly sapping his health, but none was prepared for a departure so sudden.

The end came in his beloved Vienna where he spent almost all of his life of 54 years. Here he completed grammar school, began and ended his university studies, and entered (1900) as assistant in the *Zentralanstalt für Meteorologie und Geodynamik*, to whose directorship he was named (1917) as successor to W. Trabert.

Doctor Exner's scientific activity was intimately connected with the development of modern meteorology. He was a self-taught meteorologist, in the sense that his university studies dealt exclusively with mathematics and physics. Since he did not avail himself of the teaching of Hann and Pernter it is to be concluded that he had no inner urge toward meteorology, but rather felt that a young physicist well grounded in mathematics would find in meteorology a wide field for activity.

Doctor Hann was probably amazed at this new meteorologist who was unacquainted with the simplest meteorological facts, but Exner demonstrated what may be accomplished when one well qualified in mathematics and physics enters the field of meteorology.

At first he did not feel entirely at home in the scientific atmosphere of the office; Hann's ideas ran along economic and statistical lines and Margules was given to extremely strict theoretical treatment of problems whose significance could not be apprehended by a meteorological novice.

From the beginning, therefore, Exner set out on a new path, the theoretical development of synoptic meteorology which appeared to him to hold the chief problem of all meteorology—the prediction or, indeed, the precalculation of future weather. In his first works he made the attempt, but little satisfactory, to calculate future pressure distribution from given or present distribution. The fruitful combination with Margules's line of thought resulted when he began to take into consideration temperature conditions and temperature changes.

Doctor Exner carried on a life-long struggle with the problem of the origin, movement, and transformation of the cyclone, and the fact that in this he often changed the basic conception is proof of the difficulty and ambiguity of that problem. Of Exner's work in the field of dynamic meteorology it can be said that the chief advance relative to Margules's work lies in the fact that the former consistently attempted to dovetail the results of theoretical speculation in to the practice of synoptic meteorology. In this he was like Bjerknes, although not always in agreement with that leader in theory.

A summarization of acquired knowledge was given by Exner in his *Lehrbuch der dynamischen Meteorologie*, and through this he became the teacher of the younger generation of meteorologists far beyond the limits of Germany. In addition to the dynamic problem he gave attention to meteorological optics, mainly for the reason that the *Lehrbuch der meteorologischen Optik* begun by Pernter had to be completed after that writer's death. In a very brief time, he familiarized himself with this new field and in this work attracted much interest to that long neglected subject.

It is not so well known that Exner was the first German investigator to recognize the significance of the correlation method not only in meteorology, but also in many fields of applied mathematics. The conviction that, in all probability, one could never obtain the basis for long-range prediction along the line first followed led him to approach the problem through correlation, and in this he showed the capability, not natural in a theorist, of handling an immense amount of data. His concern with such questions convinced him that in the handling of this problem of great practical importance the creation of an international institution for investigation is an unconditional necessity.

Although not a theorist of the strictest type, as Margules, he was, especially in his younger days, very averse to meteorological works that did not use differential equations. So, at first, he was not very kindly disposed toward climatology, but at the beginning of his correlation studies it became clear to him that the numerous tables published by Hann in the *Meteorologische Zeitschrift* were of value, to be sure, as data only.

After the death of Doctor Hann the work of coediting the *Meteorologische Zeitschrift* was assumed by Exner. This was an activity not in keeping with his nature and it did not give him very great pleasure. At that time the scope of the journal had to be limited for financial reasons, and the assistance given by numerous meteorologists in other countries was due in no small part to Exner's prestige in the professional world.

Soon after the close of the World War Doctor Exner was named on the International Meteorological Committee and on different commissions of that organization. He was given membership in the *Akademie der Wissenschaften* (Vienna), elected to honorary membership in the Royal Meteorological Society in 1925, and the *Preussische Akademie der Wissenschaften*. In 1922 the Berlin University proposed him as successor to Doctor

Hellmann in the direction of the *Preussisches Meteorologischen Institut*, but on account of his dislike for excessive administrative duties he remained director of the *Österreichische Zentralanstalt für Meteorologie und Geodynamik* and professor of *Physik der Erde* at the University of Vienna.

His life was rich—in labors, in results, in friends.—*Abstract from Meteorologische Zeitschrift, March, 1930, by W. W. Reed.*

Investigations of the "Vega," summer 1929, by Leonard R. Schneider.—In the *Vega* number of YMER, vols. 1 and 2, 1930, J. W. Sandström gives in an article "Den Svenska Ishavsexpeditionen, 1929," the first summary of the outstanding events and scientific results of the Swedish expedition which spent June, July, and August of the summer of 1929 in the Greenland and Barents seas collecting meteorological and hydrographical data. Eighteen pages of the article describe how the expedition was got under way and what was accomplished along various parts of the voyage. Another 11 pages describe some of the kinds of ice encountered and in this discussion explanations are given for some of the peculiar formations. The remaining 14 pages have to do mostly with the meteorological problems.

But by far, the most interesting and instructive parts of the article are the graphs which show the results of the meteorological investigations and the most outstanding of these deserve a word of explanation. One graph for a 20-year period from 1874 to 1894 shows that when the air temperature in February is warm at the west coast of Norway, the time for opening of work in April, in the Uppsala, Sweden, district, is comparatively early. When the temperature is cool in Norway, the opening of the season is several days later. In another investigation it is shown that a pressure difference of 20 millimeters between Iceland and the Azores may cause either of two distinct types of weather over Europe. The chief features of these are shown in the graphs of the four main weather types of Europe for the winter months December, January, and February during the years 1900 to 1910, and all these may be summarized by the statements which have appeared in the Meteorologishe Zeitschrift, November, 1926, but which are again given here. They are as follows:

1. Westerly wind at Lofoten between N. 50° W. and S. 70° W. gives a warm northern and a cold southern Europe.
2. North-northeasterly wind at Lofoten between N. 10° E. and N. 40° E. together with east-southeasterly wind at Lofoten between 40° E. and S. 80° E. give a cold north and a warm south Europe.
3. South wind at Lofoten between S. 30° E. and S. 40° W. gives a cold Europe and a warm Atlantic.
4. East-northeasterly wind at Lofoten between N. 50° E. and N. 80° E. gives a warm Europe and cold Atlantic.

A graph of especial significance shows the sea water surface temperatures. By drawing lines across the number of meridians which represent the temperatures of the water, the author has been able to show in graphic form the temperature for each observation. Temperature above zero appear to the right and those below zero appear to the left of the line marking the course of the vessel. Although the Gulf Stream was crossed in all four times, the increased warmth due to the lateness of the season during the last crossing from the 30th to the 24th of August is striking, the temperatures being perhaps more than a degree warmer, though the course lay farther north. Still another graph shows the vertical water temperatures to a depth of 100 meters. With a careful examination of this full page graph one is able to find his way about, but it appears as if too much has been crowded onto one page to make it have a very great significance. An enlarged graph of the July 4 to the 9 crossing is however, quite clear and in this the Gulf Stream's western limit is plainly at 0° longitude and 72° N. latitude, the water being warmest at 14° E. longitude, and 70° N. latitude with temperature of 9° C. The graph of the wind direction and force, cloudiness, air temperature, precipitation, and days with fog, also puts too much information onto one map, still, the facts are there for those who are interested in digging them out. In all, 17 graphs and 25 photographs, some of which are interesting, are included in the article.

Captain Corneliussen, skipper of the expedition's vessel, says about the weather of the region, the result of 25 years' experience in Arctic seas: "When there is fine weather in the Arctic Sea there is bad weather in northern Norway, and vise versa." The author explains this by saying that when the warm Gulf Stream lies near Norway, the ascending currents over it give rise to rain and cloudy weather, but when the edge of the pack ice is farther west and the Gulf Stream is able to spread farther westward, then the region of rainy weather is farther westward and the Norway coast region becomes a region of descending air, hence fine weather prevails there. In a somewhat similar manner the author explains the cold European winter of 1928–9. In this case the heated air rose over the exceptionally warm Gulf Stream, spread out at high levels, and then descended over the northern part of the continent, the descending air giving clear skies and consequently cold nights to bring about a general lowering of the temperature.

As a summarizing statement the reviewer agrees with Mr. Sandström that more numerous and even more complete investigations of the Gulf Stream need to be carried out before definite conclusions relating to the problems of forecasting the weather of Europe can be settled, but the reviewer is led to ask the question, why not carry on the investigations nearer the source of the Gulf Stream?

Geological climates,[1] *by G. C. Simpson, C. B., F. R. S.*—The meeting of the Royal Society on March 27 was devoted to a discussion of the subject of geological climates, which brought out several points of great interest, and showed that the conflict of view, though still considerable, is less direct than it was some years ago. In opening the discussion, Dr. G. C. Simpson defined the problem from the point of view of a meteorologist, and laid down some fundamental principles with which all reconstructions of past climates must conform. He pointed out that the earth being approximately a sphere rotating on an axis inclined at an angle of about 66½° to the plane of the ecliptic, there must always have been climatic zones in which the mean annual temperature decreased from the equator to the poles, and there must always have been summer and winter.

Doctor Simpson then passed to the conditions existing at present, and showed that in spite of the great differences in the land and sea distribution of the two hemispheres, the mean annual temperatures of corresponding latitudes between the Equator and 70° nowhere differ by more than 3° C. From this he drew the conclusions that the mean temperature in any latitude is almost entirely independent of the distribution of land and water, and that the mean temperature of corresponding latitudes is always the same in both hemispheres. Hence it is impossible to explain great changes of climate in geological periods by means of changes

[1] Reprinted from "Nature," London, Apr. 5, 1930.

in the distribution of land and sea. The reason is that the gradient of temperature from Equator to Poles is controlled by the strength of the atmospheric circulation; an increase of the gradient is automatically followed by a strengthening of the circulation, and more heat is carried from the equatorial to the polar regions until the balance is restored. The supposition that large ice sheets could exist at sea level in the Tropics, while tropical conditions prevailed in middle latitudes of the northern hemisphere, is quite untenable. The only way in which major climatic changes could be brought about was by changes of solar radiation, and these had more effect on the cloudiness and precipitation than on the temperature. Extensive changes of mean annual temperature could only be brought about by movements of the crust relative to the poles, in the manner described by Wegener.

The subsequent discussion turned mainly on two points, the value of fossil plants and animals as indices of past climates, and the power of changes in the distribution of land and sea to modify the zones of temperature and introduce major climatic variations. Prof. A. C. Seward said that the climatic value of fossil floras has been greatly overestimated in the past, and there is now no justification for speaking of the climate of the earth as having been uniform or of high northern latitudes as having been tropical. It is not possible to infer the climate from a study of extinct genera or even species, because to-day allied species often live under quite different climatic conditions. Moreover, in the course of ages, plants may have altered their constitution as they passed from youth to senility. New plant types frequently originate in Arctic regions and spread southward, while in high latitudes they are driven out by the competition of later types, but this does not necessarily imply a change of climate. The vegetation of past ages was more uniform than that of to-day, but the uniformity has often been exaggerated, because the early floras consisted exclusively of gymnosperms, which resemble each other much more closely than do flowering plants. There is no justification for the assumption that the vegetation of the coal measures was tropical; on the other hand, the presence of glaciers does not necessarily imply temperatures at freezing point, for glaciers in New Zealand still end among vegetation of subtropical aspect.

Prof. J. W. Gregory illustrated another difficulty in the interpretation of fossil floras by showing how a coal bed may be in process of formation in Jan Mayen at present, the material being supplied by timber drifted from Siberia.

Sir Peter Mitchell agreed with Professor Seward that the climatic value of fossils has been overestimated, since animals have power to adapt themselves to changing climatic conditions. He added that for animal life the range of temperature is more important than the annual mean, and the annual range is closely dependent on the distribution of land and sea.

These modifications of the former claims of palaeontologists concerning past climates represent a great advance toward the meteorological view of the permanence of climatic zones, put forward by Doctor Simpson. The gap is not entirely bridged, however, for several speakers expressed the opinion that while there must always have been zones of temperature, Doctor Simpson has underestimated the possible effects of changes in the distribution of land and sea. Professor Gregory referred to a dictum by Lord Kelvin, that if the greater part of Europe, Asia, and North America were submerged beneath the sea, the Arctic Ocean would be free of ice, and an island at the north pole would have a mild climate. Dr. C. E. P. Brooks referred to investigations by Professor Kerner and himself which led to the same conclusion, and described the transfer of heat by ocean currents, especially in the Atlantic. He pointed out that the North Atlantic between 30° N. and the Arctic Circle is, on the average, about 5° C. warmer than the South Atlantic between 30° S. and the Antarctic Circle. This difference is almost entirely due to the fact that two-thirds of the warm equatorial water is carried into the North Atlantic by the Gulf Stream and Antilles Current. In many of the geological periods the distribution of land and sea, according to the usual palaeogeographical reconstructions, was such that the whole of the warm equatorial water was diverted into the northern hemisphere, and he argued that under such conditions the oceans of the northern hemisphere must have been much warmer than those of the southern hemisphere, and the thermal equator must have been well to the north of the geographical equator. Finally, Dr. C. Tate Regan described the distribution of fresh water and marine fishes during the Cretaceous and Eocene, which does not fit in with the drift of the continents as inferred by Wegener.

The general result of the discussion may be summed up by saying that the geological changes of climate have not been so great as was at one time supposed; but there is not yet any agreement as to whether they were small enough to be accounted for by ordinary agencies, or whether they were on a sufficient scale to necessitate an appeal to movements of the continents relative to the poles.

Solar eclipse April 28, 1930, at Havre, Mont., by FRANK A. MATH.—The eclipse of the sun forecast by astronomers for April 28, 1930, was distinctly visible at Havre, Mont. Under a bright, clear sky with only a few strato cumulus clouds near the horizon and a few cirrus in the zenith from 9:40 a. m. the first contact appeared on the sun about 11:05 a. m. The observations were made by naked eye through smoked glass or old negatives of film. The sun was steadily darkened until 12:40 p. m., when only a tiny crescent was observed through the glass. It was estimated that about 95 per cent of the sun was shut from view. For 10 or 15 minutes during the darkest part of the eclipse a pale, weird, steel-blue light was seen casting peculiar shadows with needlelike or woolly edges. A faint corona appeared around the sun. The cirrus clouds near the zenith turned a blue color. Birds went to roost. After 12:45 p. m. the sun began to brighten again. The eclipse was diminishing. The last contact on the sun was seen at 1:58 p. m.

The meteorological aspects of the eclipse were the shutting off of sunlight. The station sunshine recorder stopped registration at 11:52 a. m. and continued off until 1:24 p. m. The temperature, which had risen 4° to 5° steadily from 7 a. m., reached 58.8° at 11:35 a. m., when it began to gradually fall to 55.9° at 12:40 p. m., a drop of 2.9° in 65 minutes, an unusual occurrence at that hour under a clear sky. The sensitive effect of the temperature fall was very noticeable, as we should normally have had a rise of about 5° during that interval. Most persons in this city believed that the fall was 10° or 20°. They were disappointed to learn that the thermometer readings showed only 2.9°.

A smoked glass was placed over the theodolite lens and readings taken of the sun during the eclipse. The readings showed that the sun moved in azimuth from 150° to 202°, with zero setting on north. At Havre, Mont.,

true solar noon on April 28 occurs at 12:16 p. m., one-hundred and fifth meridian standard time, at which moment the altitude of the sun read 55.5° and the azimuth 180°.

Severe drought at Washington, D. C., April–May, 1930.—During the period April 18–May 14, 1930, no measurable rain fell at Washington, D. C. The longest drought hitherto experienced was that of September 30–October 26, 1924, or a single day longer than the first-mentioned. October, 1924, was exceptionally dry in the eastern half of the country; in some sections it was the driest month of that name for 100 years, the single exception being Florida where abundant rains fell.

The drought under discussion was one of the most severe spring droughts ever experienced. As shown by the Weekly Weather and Crop Bulletin of May 6, 1930, the month of April as a whole was exceptionally dry in the Gulf States, the Ohio Valley and Tennessee, and in the Atlantic States north of Georgia.

The visible cause both of the 1924 fall drought and the 1930 spring drought was the same in the larger features, viz, the predominance of anticyclones that descended from higher latitude and the consequent blocking of the eastward movement of cyclonic storms having their origin westward over the Plateau and Rocky Mountain regions. This effect was augmented by the anticyclonic conditions over the western Atlantic which spread to the westward over the southeastern States. In the 1924 drought not a single cyclonic storm crossed the Lake region and passed down the St. Lawrence Valley, but in the 1930 drought several cyclonic storms passed to the eastward over the St. Lawrence Valley; the rainfall from them was, however, light and spotted in distribution. Thus Baltimore, Md., only 40 miles east-northeast of Washington, received showers on April 21, 1929, and May 3, aggregating 0.16 inches, and Richmond, Va., about 110 miles south, received two showers totaling but 0.10 inch. The drought was broken on May 14 by general rains over the whole of the droughty region. Curiously enough, the direct cause of the breaking of the drought was an active anticyclone whose front had reached Manitoba, just north of Lake Winnipeg, on May 12. This anticyclone caused a rather vigorous cyclone, centered on the morning of the 12th over the valley of the Red River of the North, to change its course to the eastward and eventually to move across Lake Michigan, giving off a secondary over the upper Ohio Valley that produced general rains in the droughty regions.

Study of this and previous droughts leads to the conclusion that there is a definite rain shadow east of the Appalachians when rain-producing storms come from the west and pass down the St. Lawrence Valley—*A. J. H.*

Meteorological summary for Chile, March, 1930 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—With March there came increased activity in the atmospheric circulation over the Pacific Ocean; this was accompanied by a marked increase in rainfall in the south. Mean temperatures were rather high in the central zone of Chile.

The most important anticyclones were charted during the following periods: 3d–4th, 11th–13th, and 17th–20th. All of these HIGHS moved from southern Chile toward Argentina.

The depressions causing unsettled weather and rains in the southern area were mapped during the following periods: 6th–7th, 9th–12th, 13th–14th, and 26th–28th. In all periods the path was across the extreme southern region.—*Translated by W. W. R.*

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING APRIL, 1930

By HERBERT H. KIMBALL, Solar Radiation Investigations

For reference to descriptions of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this volume of the REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged slightly below the normal intensity for April at all three stations.

Table 2 for March shows an excess in the total radiation received on a horizontal surface at Washington, Madison, Lincoln, Chicago, and Twin Falls, and a deficiency at Fresno and La Jolla. For April there was a slight deficiency recorded at Washington, Lincoln, and La Jolla, and an excess at Madison, Chicago, and Twin Falls.

TABLE 1.—*Solar radiation intensities during April, 1930*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M. 5.0	4.0	3.0	2.0	[1] 1.0	P. M. 2.0	3.0	4.0	5.0	Local mean solar time
	e.										e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Apr. 2	3.81		0.81	1.00	1.10						2.74
Apr. 4	5.36		0.53	0.73	1.07		1.13	0.86	0.61		4.37
Apr. 5	3.15		0.71	0.89	1.11						4.75
Apr. 7	5.56		0.84	1.00	1.18						6.76
Apr. 9	2.16		1.05	1.16	1.28	1.48	1.10	0.77			1.78
Apr. 10	3.99	0.47	0.62	0.75		1.35					2.74
Apr. 15	6.50			0.54							4.95
Apr. 22	7.87				0.97						7.04
Apr. 24	2.62				1.10	1.43	0.90	0.60			2.62
Apr. 25	3.81			0.84	1.07	1.46					4.17
Apr. 26	6.27			0.59	0.83	1.27					4.37
Apr. 29	8.18					1.04	0.76				4.95
Means		(0.47)	0.76	0.83	1.08	1.34	0.97	0.74	(0.61)		
Departures		−0.23	±0.00	−0.06	±0.00	−0.02	−0.12	−0.16	−0.13		

Madison, Wis.

Apr. 1	2.87						1.15				2.62
Apr. 2	3.00		0.82	0.96			1.17				2.62
Apr. 3	3.99		1.01			1.55	1.27				4.17
Apr. 4	3.81		0.72	0.81	1.12	1.42	0.96				4.57
Apr. 7	3.45		0.98	1.11	1.26		1.19				2.26
Apr. 8	2.36			1.22	1.33	1.54	1.23				1.96
Apr. 9	2.62			0.85	1.05						3.45
Apr. 14	4.75			0.77	1.03	1.38					4.57
Apr. 19	2.87			0.96	1.19	1.45					2.26
Apr. 22	2.74			1.06	1.22	1.47					2.36
Apr. 23	1.96			1.03	1.21						2.36
Apr. 24	2.26			1.02	1.20	1.47					3.00
Apr. 25	3.63			0.93	1.09		0.89				3.15
Apr. 26	4.17			0.82	1.08	1.35					3.81
Means			0.88	0.96	1.16	1.45	1.12				
Departures			−0.08	−0.09	−0.05	−0.02	−0.09				

Lincoln, Nebr.

Apr. 1	3.00			0.87	1.24						3.63
Apr. 2	3.45				1.15		1.05	0.78			5.79
Apr. 3	3.99			1.06	1.21		1.06	0.93	0.79	0.71	7.04
Apr. 6	3.45						1.22	1.06	0.90	0.79	4.75
Apr. 7	2.26		1.09	1.19	1.36	1.49					3.30
Apr. 22	4.57				1.19						3.30
Apr. 24	4.17		0.68	0.87	1.07						4.37
Means			(0.88)	1.00	1.20	(1.49)	1.11	0.92	(0.84)	(0.75)	
Departures			+0.04	+0.02	−0.01		−0.06	−0.06	−0.01	+0.03	

[1] Extrapolated.

Skylight polarization measurements obtained on eight days at Washington give a mean of 46 per cent and a maximum of 60 per cent on the 9th. These are slightly below the corresponding averages for April at Washington. At Madison measurements obtained on 11 days give a mean of 58 per cent with a maximum of 70 per cent on the 8th. These are close to the corresponding averages for April at Madison.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram calories per square centimeter]

Week beginning	Average daily totals: Washington	Madison	Lincoln	Chicago	New York	Pittsburgh	Gainesville	Twin Falls	Fresno	La Jolla
1930										
Apr. 2	339	518	550	393	----	285	525	423	560	421
Apr. 9	455	341	430	409	----	332	548	380	569	411
Apr. 16	327	296	333	240	----	269	519	561	614	475
Apr. 23	478	475	261	407	----	276	605	491	576	466
	Departures from weekly normals									
Apr. 2	−48	+134	+124	+106	----	----	----	+39	+32	−7
Apr. 9	+56	−60	+14	+97	----	----	----	−44	+3	−32
Apr. 16	−87	−103	−98	−68	----	----	----	+96	+20	+22
Apr. 23	+56	+45	−199	+86	----	----	----	−41	−56	−10
Accumulated departures on Apr. 29	−371	−112	−490	+2,289	----	----	----	+2,261	−799	−2,401

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1930										
Feb. 26	290	299	405	210	----	150	420	284	266	329
Mar. 5	260	309	380	220	----	236	367	314	400	339
Mar. 12	369	336	351	220	----	265	258	300	382	296
Mar. 19	398	283	360	226	----	292	476	419	511	402
Mar. 26	386	424	504	223	----	254	483	447	491	378
	Departures from weekly normals									
Feb. 26	+3	+12	+56	+17	----	----	----	+27	−80	−25
Mar. 5	−56	+14	+26	+22	----	----	----	+34	+35	+4
Mar. 12	+41	+13	−21	+10	----	----	----	−10	−23	−40
Mar. 19	+38	−42	−43	+4	----	----	----	+87	+39	+28
Mar. 26	+33	+57	+94	−15	----	----	----	+102	−24	−29
Accumulated departure on Apr. 1	−210	−224	+623	+742	----	----	----	+1,911	−792	−2,212

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. V. K. Coman, Acting Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1930	h m	°	°	°			
Apr. 1 (Naval Observatory).	11 43	−79.5	307.3	+14.0	----	278	----
		−28.0	358.8	−13.0	6	----	----
		−4.0	22.8	−5.5	----	370	----
		+37.0	63.8	+8.5	----	77	----
		+37.0	63.8	−16.0	28	----	759
Apr. 2 (Naval Observatory).	10 58	−68.5	305.5	+12.5	----	617	----
		+10.5	24.5	−5.0	----	401	----
		+52.0	66.0	+7.5	----	77	----
		+65.0	79.0	+8.0	----	93	1,188
Apr. 3 (Mount Wilson)	13 0	−56.0	303.6	+13.0	----	435	----
		−9.0	350.6	−20.0	----	2	----
		+26.0	25.6	−5.0	----	467	----
		+69.0	68.6	+9.0	----	51	----
		+76.0	75.6	+7.0	----	10	965
Apr. 4 (Naval Observatory).	11 5	−42.5	305.0	+12.5	----	494	----
		+40.0	27.5	−5.5	309	----	803
Apr. 5 (Naval Observatory).	11 13	−76.0	258.2	+15.5	31	----	----
		−69.5	264.7	−6.5	----	28	----
		−28.5	305.7	+13.0	----	540	----
		+54.0	28.2	−5.0	278	----	877

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
	h m	°	°	°			
Apr. 6 (Mount Wilson)	18 15	−60.0	257.2	+16.0		13	
		−53.0	264.2	−7.0		11	
		−29.0	288.2	+9.0	8		
		−7.0	310.2	+13.0		529	
		+69.0	26.2	−5.0	346		907
Apr. 7 (Naval Observatory).	10 41	−49.5	258.6	+15.0		62	
		−41.5	266.6	−7.0		31	
		−19.0	289.1	+8.0	6		
		−0.5	307.6	+13.0		448	
		+80.5	28.6	−5.0	185		732
Apr. 8 (Naval Observatory).	11 38	−61.5	232.9	−7.5		19	
		−37.0	257.4	+15.0		123	
		+13.5	307.9	+12.5		401	543
Apr. 9 (Naval Observatory).	10 53	−62.0	219.6	+14.0		19	
		−47.5	234.1	−8.0		31	
		−41.0	240.6	+12.0	9		
		−20.5	261.1	+15.0	25		
		+29.5	311.1	+12.0	355		439
Apr. 10 (Naval Observatory).	11 7	−49.0	219.3	+14.0		123	
		−35.0	233.3	−7.0		9	
		−8.0	260.3	−11.5	3		
		−6.5	261.8	+15.0	12		
		+23.5	291.8	+8.0	19		
		+42.0	310.3	+12.0	355		521
Apr. 11 (Naval Observatory).	11 2	−38.0	217.2	+13.5		185	
		−20.5	234.7	−7.0		62	
		+6.0	261.2	+15.0	6		
		+55.0	310.2	+12.0	340		593
Apr. 12 (Naval Observatory).	11 27	−25.0	216.7	+14.0		185	
		−7.5	234.2	−7.5		77	
		+17.0	258.7	+15.0		37	
		+67.5	309.2	+12.0	340		639
Apr. 13 (Naval Observatory).	11 6	−51.5	177.2	+15.5	6		
		−11.5	217.2	+14.5		170	
		+4.0	232.7	−8.0		93	
		+32.0	260.7	+14.5	3		
		+81.5	310.2	+12.0	370		642
Apr. 14 (Naval Observatory).	11 15	−38.5	176.9	+15.5		12	
		+1.5	216.9	+15.0		108	
		+18.0	233.4	−7.0		93	
		+69.0	284.4	−11.5	22		235
Apr. 15 (Naval Observatory).	13 10	−25.0	176.2	+15.5	6		
		+17.0	218.2	+14.5		22	
		+30.0	231.2	−10.0		12	40
Apr. 16 (Mount Wilson).	13 15	+30.0	217.9	+15.0		21	
		+42.0	229.9	−13.0		65	
		+55.0	242.9	+12.0	9		95
Apr. 17 (Perkins Observatory).	11 39	−33.7	141.7	−19.4	78		
		−22.4	153.0	−20.0	31		109

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
	h m	°	°	°			
Apr. 18 (Naval Observatory).	12 1	−66.5	95.7	−11.0	6		
		−48.0	114.2	+27.5		19	
		+56.0	218.2	+15.0	9		
		+70.0	232.2	−11.5	19		53
Apr. 19 (Mount Wilson)	12 0	−55.0	94.0	−13.0		80	
		−40.0	109.0	+28.0	16		
		+30.0	179.0	+14.0		9	105
Apr. 19 (Yerkes Observatory).	11 52	−56.5	92.6	−12.0	21		
		−55.5	93.6	−13.5	26		
		−51.5	97.6	−13.0	64		
		−37.5	111.6	+28.0	20		131
Apr. 20 (Naval Observatory).	10 54	−40.5	95.9	−12.5		22	
		−24.0	112.4	+28.0		77	
		+43.5	179.9	+15.0	9		108
Apr. 21 (Naval Observatory).	10 51	−30.0	93.2	−12.0		19	
		−10.5	112.7	+27.5		31	
		+56.0	179.2	+15.0	9		59
Apr. 22 (Naval Observatory).	11 30	−89.0	20.6	−6.0	170		
		−17.5	92.1	−11.5	12		182
Apr. 23 (Naval Observatory).	11 21	−76.5	20.0	+12.5	9		
		−65.5	31.0	−6.0	185		
		−1.0	95.5	−12.0	6		
		+60.0	156.5	−6.0	6		206
Apr. 24 (Naval Observatory).	11 00	−61.0	22.5	+13.0	15		
		−52.5	31.0	−6.0	201		216
Apr. 25 (Naval Observatory).	10 59	−47.0	23.3	+12.5	9		
		−39.0	31.3	−6.0	216		
		+7.5	77.8	+9.0	3		
		+30.0	100.3	−12.0	2		230
Apr. 26 (Naval Observatory).	10 54	−57.0	0.1	−4.0	3		
		−35.0	22.1	+13.5		46	
		−26.0	31.1	−6.0	201		
		+37.5	94.6	+7.5	6		
		+42.5	99.6	−12.0	6		262
Apr. 27 (Naval Observatory).	10 6	−21.5	22.8	+13.5		62	
		−13.5	30.8	−6.0	216		278
Apr. 28 (Naval Observatory).	11 33	−7.5	22.8	+13.5		77	
		+1.0	31.3	−6.0	231		308
Apr. 29 (Naval Observatory).	10 57	−33.5	343.9	+11.5		53	
		+5.5	22.9	+13.0		170	
		+14.0	31.4	−7.0	185		408
Apr. 30 (Naval Observatory).	10 59	−20.0	344.2	+11.5		154	
		+19.0	23.2	+13.0		170	
		+26.5	30.7	−7.0	185		509
Mean daily area for April							434

AEROLOGICAL OBSERVATIONS

By RICHMOND T. ZOCH

Free-air temperatures were above normal at all the levels at Broken Arrow, Ellendale, and Royal Center and at some of the levels at Due West and Groesbeck. At Ellendale these positive departures were very large.

Free-air relative humidities were below normal at most levels at all of the stations.

Free-air vapor presures were mostly above normal at Broken Arrow, Ellendale, and Royal Center and below normal at Due West and Groesbeck. The vapor pressure departures followed the trend of the temperature departures.

The resultant winds were variable from the surface to the 1,500-meter level. Above this level they were westerly.

Airplane observations made at the naval air station, Seattle, Wash., have been included in Table 2.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during April, 1930*

TEMPERATURE (° C.)

Altitude meters m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	15.8	+0.2	15.2	−1.4	8.8	+3.2	17.6	−0.4	10.7	+0.3
500	15.5	+1.6	14.4	0	8.6	+3.4	17.6	+1.9	9.2	+1.3
1,000	14.4	+2.9	11.9	+0.2	6.3	+3.6	15.7	+1.7	7.2	+1.7
1,500	12.7	+3.3	9.1	+0.2	4.0	+3.5	14.0	+1.2	4.4	+1.1
2,000	9.7	+2.6	6.2	+0.2	1.9	+4.0	11.0	+0.3	2.5	+1.6
2,500	6.4	+2.2	4.0	+0.3	−0.9	+4.0	7.5	−0.6	0.3	+2.0
3,000	2.8	+1.7	0.9	−0.1	−4.0	+3.9	4.1	−1.1	−2.1	+2.2
4,000	−4.2	+0.8	−4.7	−0.5	−9.2	+4.8	−3.4	−2.3	−8.4	+1.1
5,000	−9.8	+0.9			−16.0	+3.8			−14.6	+0.7

RELATIVE HUMIDITY (%)

Surface	65	+1	62	0	58	−7	75	+2	67	+2
500	62	−1	56	−6	58	−6	61	−10	65	0
1,000	53	−7	54	−7	56	−4	52	−10	64	+2
1,500	50	−5	53	−7	53	−4	38	−11	65	+6
2,000	48	−2	48	−9	48	−7	37	−6	60	+3
2,500	49	0	45	−7	48	−6	39	−2	54	+2
3,000	55	+7	46	−4	50	−4	37	−3	50	0
4,000	51	+6	46	0	48	−8	40	−3	43	−6
5,000	39	−7			44	−10			39	−5

VAPOR PRESSURE (*mb.*)

Surface	11.66	−0.18	10.85	−1.08	6.45	+0.61	15.11	−0.33	8.92	+0.29
500	10.84	+0.44	9.38	−1.04	6.37	+0.69	11.62	−1.45	7.85	+0.49
1,000	8.67	+0.28	7.74	−0.99	5.43	+0.90	8.75	−1.39	6.87	+0.88
1,500	7.15	+0.48	6.38	−0.71	4.50	+0.80	5.93	−1.22	5.95	+1.01
2,000	5.56	+0.46	4.82	−0.53	3.67	+0.70	4.76	−0.59	4.87	+0.87
2,500	4.46	+0.37	3.80	−0.16	3.00	+0.60	4.23	−0.03	3.79	+0.74
3,000	3.90	+0.63	2.87	−0.16	2.60	+0.67	3.36	−0.07	2.96	+0.55
4,000	1.81	−0.20	2.59	+0.70	1.75	+0.47	1.80	−0.54	1.46	−0.17
5,000	0.53	−0.82			1.29	+0.51			0.31	−0.81

TABLE 2.—*Free-air data obtained at Naval Air stations during April, 1930*

Altitude m. s. l. (meters)	Temperature (°C.)				Relative humidity (%)			
	Pensacola, Fla.	San Diego, Calif.	Seattle, Wash.	Washington, D. C.	Pensacola, Fla.	San Diego, Calif.	Seattle, Wash.	Washington, D. C.
Surface	18.0	17.9	12.3	10.5	80	69	70	61
500	17.6	13.9	8.6	8.4	65	81	73	57
1,000	15.9	12.8	5.6	6.0	59	64	71	57
2,000	10.4	9.6	0.0	1.4	50	38	61	57
3,000	5.2	3.5	−5.2	−2.9	36	22	59	47
4,000			−11.1				54	
5,000			−18.1				54	

TABLE 3.—*Observations by means of kites, captive and limited-height sounding balloons during April, 1930*

	Broken Arrow, Okla.	Due West, S. C.	Ellendale N. Dak.	Groesbeck, Tex.	Royal Center, Ind.
Mean altitudes (meters) m. s. l., reached during month	2,810	2,846	2,987	2,499	2,981
Maximum altitude (meters) m. s. l., reached and date	[1] 6,175	[2] 4,075	[3] 5,429	[4] 4,195	[5] 5,678
Number of flights made	30	33	32	30	32
Number of days on which flights were made	27	28	30	28	30

[1] 14th. [2] 1st. [3] 2d. [4] 29th. [5] 30th.

In addition to the above there were approximately 125 pilot balloon observations made daily at 53 Weather Bureau stations in the United States.

TABLE 4.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during April, 1930*

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,868 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (65 meters)		Key West, Fla. (11 meters)		Los Angeles, Calif. (40 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°	
Surface	S 23 E	1.7	S 33 W	1.7	N 88 W	3.5	N 73 E	0.3	N 36 W	0.9	S 5 E	2.1	S 52 W	0.7	N 32 W	0.4	N 85 E	2.4	N 60 W	1.5
500	S 3 W	5.4	S 64 W	3.8			N 49 W	1.3	N 12 E	0.7	S 12 W	8.3			N 76 E	1.0	S 81 E	5.3	N 87 E	0.9
1,000	S 32 W	7.7	N 85 W	5.2			N 70 W	1.8	N 50 E	1.3	S 17 W	6.7	S 50 W	2.4	N 72 E	1.0	S 61 E	3.7	N 10 E	0.8
1,500	S 55 W	6.9	N 54 W	7.3			N 55 W	3.2	N 36 W	2.5	S 29 W	4.3	S 87 W	4.5	N 2 E	0.9	S 16 E	1.0	N 62 W	1.9
2,000	S 81 W	6.7	N 56 W	9.2	N 81 W	5.6	N 67 W	5.4	N 37 W	6.1	S 35 W	2.2	N 87 W	5.4	N 84 W	2.0	S 40 W	2.2	S 83 W	2.6
2,500	S 85 W	8.3	N 64 W	12.5	N 69 W	6.6	N 66 W	6.5	N 42 W	7.0	N 72 W	2.3	S 86 W	7.3	N 51 W	1.9	S 49 W	1.9	S 66 W	1.9
3,000	S 74 W	8.1	N 63 W	15.3	N 68 W	6.6	N 72 W	8.4	N 51 W	8.1	N 71 W	4.0	S 88 W	8.6	N 57 W	2.1	N 87 W	2.0	S 67 W	3.2
4,000	N 63 W	9.5	N 69 W	13.9	N 73 W	6.6	N 69 W	8.9	N 54 W	13.2	N 45 W	5.5	S 89 W	9.3	N 63 W	5.9	N 79 W	5.7	S 47 W	4.1
5,000					S 63 W	6.5	N 74 W	8.5	N 60 W	11.1			N 84 W	12.5	S 78 W	3.8	N 69 W	8.8		

Altitude (meters) m. s. l.	Medford, Oreg. (446 meters)		Memphis, Tenn. (145 meters)		New Orleans, La. (25 meters)		Omaha, Nebr. (313 meters)		Royal Center, Ind. (225 meters)		Salt Lake City, Utah (1,280 meters)		San Francisco, Calif. (60 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (14 meters)		Washington, D. C. (5 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°	
Surface	N 53 W	0.2	S 4 E	1.3	N 58 E	0.6	N 83 E	0.8	S 27 E	0.6	S 17 E	2.7	S 32 W	0.6	N 20 W	0.6	S 34 E	0.7	N 58 W	0.5
500	N 54 W	0.3	S 49 W	2.9	S 67 E	2.8	S 36 E	2.3	S 50 W	2.8			S 82 W	2.6	S 4 E	0.2	S 13 W	2.5	N 73 W	5.1
1,000	S 13 W	0.9	S 89 W	4.5	S 27 W	2.8	S 84 W	2.6	S 84 W	5.7			S 89 W	3.7	N 46 W	3.2	S 7 W	3.6	N 68 W	7.2
1,500	S 4 E	2.6	N 86 W	5.7	S 8 E	0.1	N 64 W	4.6	N 77 W	6.8	S 17 E	5.0	S 65 W	3.5	N 47 W	4.2	S 25 W	3.8	N 60 W	10.1
2,000	S 22 W	5.3	N 88 W	6.1	N 44 W	1.7	N 46 W	9.0	N 80 W	8.4	S 84 W	4.4	S 51 W	3.8	N 46 W	5.9	S 35 W	4.5	N 72 W	8.6
2,500	S 26 W	7.5	N 77 W	6.9	N 50 W	2.3	N 46 W	9.9	N 72 W	9.1	S 36 W	4.6	S 24 W	2.7	N 58 W	8.1	S 58 W	4.9	W	9.9
3,000	S 31 W	8.4	N 79 W	6.5	N 36 W	2.1	N 52 W	10.3	N 58 W	10.5	S 60 W	5.4	S 5 W	2.1	N 56 W	6.6	S 50 W	6.2	N 86 W	10.8
4,000	S 49 W	10.0	N 87 W	5.2	N 61 W	4.0	N 80 W	7.9	N 49 W	14.8	S 56 W	6.8			N 61 W	8.6				
5,000					N 75 W	4.4			N 66 W	13.7	S 65 W	5.2			N 66 W	8.9				

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By M. C. BENNETT

GENERAL SUMMARY

The weather for April was decidedly warmer than normal except in the Northeast where it was abnormally cold during the latter part of the month as far south as North Carolina and Tennessee, while in the South generally about normal temperatures prevailed.

The precipitation for the month was deficient in most sections. However, rather heavy amounts were received in the Southeast over much of Georgia and Florida, while in the central Great Plains, portions of the northern Rocky Mountain and Plateau regions and in parts of the Lake region and upper Mississippi Valley the monthly totals were above normal. On the other hand only small amounts were received over most other sections; they were markedly deficient from the Ohio Valley southward to the Gulf and westward to Oklahoma and central Texas, while in some sections of the far Southwest the month was rainless, and nearly all sections west of the Great Plains, except the far North, received only scanty amounts. The severe drought that had prevailed for some time in portions of the Southwest was generally relieved the latter part of the month. On the other hand droughty conditions have developed in many sections of the East and the Mississippi Valley from Missouri and central Illinois to the Gulf.

PRESSURE AND WINDS

The month opened with high pressure and fair weather in the Southeast, while elsewhere generally low pressure prevailed with light snow over portions of the Lake region and a few scattered localities to the westward. During the next several days precipitation prevailed in many localities of the East, accompanied by thunderstorms and rather heavy rain in portions of the Southeast, while from the Rocky Mountain region westward no precipitation was reported during the first decade of the month, except in the north Pacific region where light rain fell every day after the 2d, and a few scattered showers were received in the central Plateau region during the latter part of the decade. From the 4th to the 8th a low-pressure area moved from the west Gulf region easterly and northeasterly along the coast, accompanied by light to moderate precipitation in the South, but as the storm progressed northward it increased in intensity, and generous to heavy precipitation prevailed on the 7th and 8th in many localities of the Northeast. This storm was followed by a high-pressure area accompanied by fair weather which overspread most sections east of the Rocky Mountains by the end of the decade.

During the first half of the second decade generally high pressure and fair weather prevailed throughout much of the South, while relatively low pressure obtained over the northern half of the country east of the Rocky Mountains, with occasional light rains in many localities.

On the 13th a low-pressure area accompanied by generous precipitation appeared in the north Pacific area, and during the next two days overspread the Pacific States and the northern Plateau region; by the 15th this low area had extended to the southern Rocky Mountain region, and thence it moved slowly northeastward to the Lake region, and passed out the St. Lawrence Valley near the end of the second decade. It was accompanied by much rainy weather from the 15th to the 19th over most sections east of the Rocky Mountains, with thunderstorms in many localities and some rather heavy precipitation. On the 20th and 21st light rains occurred in the central valleys, the lower Lake region and to the eastward, also locally in the Southeast with some heavy thunderstorms in portions of the Florida Peninsula. Light precipitation also prevailed in portions of the North Pacific States. During the next several days relatively high pressure and generally fair weather prevailed over most sections east of the Rocky Mountains, save for a few scattered showers locally.

About the 24th generally low pressure accompanied by moderate precipitation overspread the Pacific States, and by the 26th and 27th, had extended over much of the Plateau and Rocky Mountain and western Great Plains regions, some heavy thunderstorms accompanied by severe winds and destructive hail occurred in several portions of the Southwest. The storm largely dissipated during the next day, but during the last two days of the month relatively low pressure prevailed from the Great Plains westerly to the Pacific, with widespread but moderate precipitation over much of this region, while from the Mississippi River eastward generally fair weather prevailed.

Chart VI and the insets of Charts II and III present the usual information about the mean pressure of the month.

Severe local storms were reported in considerable number, as usually happens with the advance of spring. The customary table of these storms may be found at the end of this section.

TEMPERATURE

The month was mainly much warmer than normal, the notable exception being the cold spell during the final decade affecting most central and eastern portions.

The first week, while decidedly warm in the western half, was mostly but a little warmer than normal in the eastern half of the country, and in considerable portions of the Ohio Valley and the Middle Atlantic States averaged a trifle colder than normal. Except in part of Florida the second week was everywhere warmer than normal, with marked excess of temperature over the Plains region, the Ohio and middle and upper Mississippi Valleys and the upper Lake region. After the middle of the month warmth continued to prevail in the majority of States, but the weather became somewhat cooler from the northern half of the Plains eastward. About the 22d to 24th a cold wave, well-developed for late April, set in over the north-central portions and districts to eastward as well as many portions to southward. This cold area continued for several days to dominate the weather in the lower Lake region and the interior portions of the Middle and North Atlantic States, but gave way to milder weather before the month closed. The final portion of the month was mainly a little warmer than normal in the western third of the country and the west Gulf region, but some portions of the Southwest and of the Pacific States were slightly cooler than normal at this time.

The month averaged warmer than normal everywhere west of the Mississippi River and in nearly all southern districts to eastward, also in practically all of the Ohio Valley and the upper Lake region and in some portions

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of the lower Lake region and southeastern New England. In a strip east of the Rocky Mountains, from Montana to west-central Texas, the excess of temperature was 8° to 9° per day, and from the interior of the Pacific States to the Mississippi River it was usually at least 4° per day.

From central Virginia and the eastern part of Lake Erie northeastward, April averaged in most districts moderately colder than normal.

From Montana, Idaho, and eastern Washington southeastward over the Rocky Mountain and Plains States, the month was the warmest April or almost the warmest to be found in the records. The highest temperatures recorded about the 8th to 12th from the vicinity of the Black Hills eastward and southeastward to the coasts of Virginia and the Carolinas were the highest April marks ever noted at a large proportion of the stations, and at many others they exceeded the previous highest marks of the first half of April. This five-day period included the highest marks of the month in almost two-thirds of the States. However, several Plateau and Pacific States noted the highest late in the first week of April, and the reading of 108° on the 6th in Arizona, was the highest temperature reported anywhere within the country. Parts of the extreme Northwest noted their highest marks on the 21st and some portions of the Northeast within a few days of the end of the month.

The lowest marks were almost everywhere within previous records. Nearly all States west of the Mississippi River, also some northern States as far east as Ohio and Michigan, recorded them on the 1st or 2d. Several States from Mississippi northeastward to New England reached their lowest temperatures on the 8th, 9th, or 10th, and North Carolina, Kentucky, and the Southern Middle Atlantic States on the 24th or 25th. The very lowest was −4° on the 1st at an elevated point in Wyoming. In every State save the few that border the Gulf of Mexico and nowhere attain an elevation of a thousand feet, there was some point where freezing was recorded.

PRECIPITATION

In only one-seventh of the States did the April precipitation equal or exceed the normal and in several South Central and Southeastern States it averaged less than half of the normal. Furthermore the distribution in point of time was especially unfavorable in many districts. The first 10 or 15 days were mainly dry and in numerous localities without appreciable rain in the Plains, the Central Valleys and the western part of the Lake region. Much of Arkansas and Louisiana, and a large portion of the country south of the Ohio River received no rain of any consequence after the 6th or 7th until the very last day or two, or in some cases till after April ended.

The April precipitation was greater than normal in most of Florida and some parts of Georgia and South Carolina, in a few parts of the Lake region, and especially in most of the middle and northern Plains and much of western and southern Texas. For the most part the northernmost districts from Montana to the Pacific coast had an excess, also a large portion of Oregon.

Most of the Southwest had a deficiency, likewise the greater part of Wyoming. In sections where liberal rains are expected in April the deficiency was most marked from the eastern portions of Oklahoma and Texas eastward to include the southern and central Appalachian region and northward to include all the basin of the Ohio River. Numerous stations in this area found this the dryest April shown by their records.

In substantially all portions of the country for which the amounts have not been specified by the preceding paragraphs, the precipitation of April fell short of normal, but not to a marked degree.

In the eastern half of the country, as a whole, the forest-fire hazard was as great or greater this April than in any other spring month for many years, and the fire losses reported were unusually large. In numerous States this situation continued well into May.

The largest amount of precipitation reported at any station during the month of April, 1930, was 14.45 inches, at a place in western Washington. Away from the immediate Pacific coast the greatest quantity measured was 13.51 inches, at Sinton, in southeastern Texas.

SNOWFALL

The snowfall of April was of little importance. The eastern portion of Ohio, northwestern Pennsylvania, the vicinity of Lake Ontario and most parts of the middle and northern Appalachians recorded moderate amounts, though usually less than the average falls indicated by previous April records. In east-central Wisconsin and northern lower Michigan there were moderate falls, also in north-central Nebraska and part of the Black Hills region. Except for these districts just noted the month brought decidedly little snow throughout the region from western Wisconsin and the western shores of Lake Superior to the northern foothills of the Rocky Mountains.

In the higher portions of the far West the April snowfall was mainly below normal, and in Wyoming it was particularly scanty. The outlook does not favor a prolonged ample flow in most of the rivers of the West that are fed considerably by melting snows.

RELATIVE HUMIDITY

The dry conditions existing over the country as a whole are reflected by the humidity percentages, which over much of the country are found distinctly below the normal, the deficiencies ranging as great as 22 per cent in some portions of the Southeast. On the other hand they were above the normal generally where the precipitation was greater than the average, as in the Florida Peninsula, and portions of the Lower Lakes, central Great Plains, northern Rocky Mountains, northern Pacific and central Plateau regions.

SEVERE LOCAL STORMS, APRIL, 1930

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Pharr, Tex. (near)	3	4:30 p. m.	2 mi.		$38,000	Tornado and hail	Damage chiefly to crops; 1 person injured	Official, U. S. Weather Bureau.
Malta, Mont., and vicinity	4				6,000	Wind	Character of damage not reported	Do.
Lee and Madison, Fla.	6	5:15 p. m.			3,300	Wind and hail	Minor crop injury; frame covering of 22 acres of tobacco damaged.	Do.
Greenville, S. C.	7					Wind	Trees, poles, and windows damaged	Do.
Maryland	7	10 a. m.–1 p. m.		2	50,000	Thunder gusts	Considerable damage to trees, buildings, and farm property throughout the section; a teacher and 15 pupils injured.	Do.
Dallas-Fort Worth, Tex., and vicinity.	13	6:15 p. m.			100,000	Hail and wind	Public utilities crippled; shacks unroofed; shrubbery broken. Some damage by lightning.	Do.
Bend, Calif.	14	2 p. m.				Hail	Fruit and vegetables injured	Do.
Almena, Kans. (near)	14	3:30 p.	1,760			Heavy hail	Windows broken; auto tops and roofs pierced; fruit damaged.	Do.
Goulds and Perrine, Fla. (west of).	15	3–4 p. m.	12 mi.		100,000	Hail	Tomatoes and other vegetables damaged; poultry raisers suffered heavy losses.	Do.
Hillsboro, Tex.	15	8 p. m.	880		20,000	Hail and wind	Windows, awnings, outhouses, smokestacks, and barns damaged.	Do.
National Gardens, Fla. (near Daytona Beach).	15				6,000	Wind, rain, and hail.	Considerable damage to gardens and ornamental flowers.	Do.
Ulysses, Kans. (5 miles west of).	16	2:30 p. m.	50		1,500	Tornado	A residence and several small buildings damaged; an oil derrick wrecked; path 5.5 miles long.	Do.
Spottsville, Ky.	17	P. m.			3,000	Whirlwind	2 barns demolished and an orchard uprooted	Do.
Sparta, Ill. (north of)	17	6 p. m.	150		10,000	Tornado	Buildings damaged, some loss of livestock; path 9 miles long.	Do.
Beaver City, Nebr.	17	7–7:20 p. m.	5–20 mi.		1,000	Hail	Considerable damage to trees and roofs over small area; path 30 miles.	Do.
McAllen, Tex.	24	3:10 p. m.	1,760		75,000	do	Heavy damage to property over small area	Do.
Honey Grove, Tex.	26	3:30 p. m.	1,320		5,000	do	Considerable crop injury; damage to buildings slight.	Do.
Dallas, Tex., and vicinity	26	4:45 p. m.				2 thunderstorms, hail, and wind.	Some damage to buildings; crops and fruit injured.	Do.
Cleburne, Tex.	26	5 p. m.	2 mi.			Hail	Gardens, orchards, and shrubbery injured	Do.
Grapevine, Tex. (near)	26	5 p. m.	2 mi.			do	Corn and gardens damaged	Do.
Garland, Tex.	26	6 p. m.				Hail and rain	Considerable damage to buildings; rain damaged merchandise.	Do.
Waco, Tex.	26	6:45 p. m.	2 mi.		35,000	Hail	Chief damage to crops; considerable damage to roofs, windows, etc.	Do.
Itasca (near), Brandon and Hubbard (near), Tex.	26	7:45 p. m.	4 mi.		35,000	Hail and wind	Buildings damaged; crops injured	Do.
Kaufman (near) and Crandall, Tex.	26	8 p. m.	3 mi.		115,000	Hail, wind, and rain.	25,000 acres of cotton damaged; gardens and truck crops ruined; some damage to buildings.	Do.
China Springs, Clifton and Meridian, Tex.	27	8 p. m.	2 mi.			Hail	Practically all crops in path destroyed	Do.
Sinton, Tex.	28	12:30 p. m.	1,760		55,000	Hail, rain, and tornado.	Small buildings wrecked; crops ruined	Do.
Taft, Tex.	28	1 p. m.	10 mi.			do	5,000 acres of cotton ruined; a few houses and barns damaged.	Do.
Scotts Bluff, Tex. (northwest of).	28	5–6 p. m.	3 mi.		20,500	Hail	Some damage to crops and buildings over path 10 miles long.	Do.
Murray County, Okla.	29	10 p. m.	20 mi.			do	Damage chiefly to roofs and crops	Do.
McAllen, Tex.	29				50,000	Rain and hail	Considerable damage to crops and buildings	Do.
Danbury, Iowa (near)	30					Hail	Glass in hot beds and greenhouses broken	Do.

[1] Mi. signifies miles instead of yards.

RIVERS AND FLOODS

By R. E. SPENCER

The Tallahatchie River, after remaining above flood stage at Swan Lake, Miss., for 82 days, fell below that point on April 6. The crest stage—31.9 feet—which prevailed from January 27 to 29, was the highest of record at Swan Lake, having exceeded by 0.1 foot that of March 22, 1927. Relative to the consequences of this flood, the official in charge of the Weather Bureau office at Vicksburg, Miss., reports as follows:

The area overflowed—about 4,800 square miles—is mostly uncultivated, but about 200 bales of cotton remained in the fields and were lost. This was practically the only tangible damage, although many minor inconveniences were suffered by residents of the overflowed section.

Fortunately the flood subsided in time for the cultivation of the cleared portion of the overflowed area during the present crop season.

Of other April floods, those in the Altamaha, Ocmulgee, Wabash, Rio Grande, and Colorado Rivers were without consequence; those in the Illinois (reported of minor importance) and Verdigris will be discussed in the May REVIEW; and that in the Sulphur overflowed about 100 acres of farm land and did approximately $300 damage to prospective crops.

Flood stages and dates appear in the following table:

[All dates in April unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	State	Date
ATLANTIC DRAINAGE	*Feet*			*Feet*	
Altamaha: Everett City, Ga.	10	(1)	4	10.4	Mar. 24–25
		10	20	10.2	14–15
Ocmulgee: Abbeville, Ga.	11	9	12	11.7	10–11
MISSISSIPPI DRAINAGE					
Wabash: Covington, Ind.	16	21	21	16.0	21
Illinois:					
Morris, Ill.	13	17	25	15.2	22
Peru, Ill.	14	Mar. 31	11	15.8	3–4
		16	(2)	18.8	23
Henry, Ill.	10	19	(2)	13.3	25
Peoria, Ill.	18	21	(2)	19.9	26
Havana, Ill.	14	20	(2)	16.2	28–29
Beardstown, Ill.	14	21	(2)	16.8	30
Pearl, Ill.	12	28	(2)	12.7	May 1–4
Verdigris: Independence, Kans.	30	30	(2)		
Tallahatchie: Swan Lake, Miss.	25	(1)	6	31.9	Jan. 27–29
Sulphur: Ringo Crossing, Tex.	20	28	28	21.5	28
WEST GULF DRAINAGE					
Rio Grande: San Marcial, N. Mex.	3	12	20	3.7	15–18
		24	(2)	3.8	28
PACIFIC DRAINAGE					
Colorado: Parker, Ariz.	7	15	(2)		

[1] Continued from last month.
[2] Continued at end of month.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, APRIL, 1930

By J. B. KINCER

General summary.—During the first decade moderate temperatures and generally fair weather made conditions favorable for farm work, except in the Southeast, where frequent rains interfered, and in the Southwest, where the soil was too dry. Rains in the Middle Atlantic States were favorable, but farther south they were too frequent and kept the gound too wet. The soil was becoming rather dry generally outside of this area, though deficiencies in moisture were not serious, except in the Southwest. In western grazing sections warm weather was generally beneficial for stock interests, particularly for lambing, but in the Southwest, especially in Kansas and Oklahoma, the drought was intensified, with conditions serious.

During the second decade rains materially improved soil condition in the Atlantic States, the northern and western Ohio Valley, and a large area of the central-north. Showers were largely local in character in the Southwest, with droughty conditions still unrelieved in much of Kansas, central and western Oklahoma, and western Texas. In general, conditions were mostly favorable over the northern half of the country, with rains helpful; in the South farm work progressed rapidly, although rains would have helped in many parts.

During the last decade there were two overshadowing features of the weather—damaging frost in the East and beneficial rains in the Southwest. In the Eastern States, especially the Appalachian Mountain sections, frost and freezing temperatures did extensive and in many places severe harm to fruit and truck crops. There was also more or less damage over a large area from western North Carolina, southwest Virginia, and eastern Kentucky northward to Pennsylvania. Over the western half of the country the period was generally favorable, the widespread rains in many sections being especially beneficial. In the Southwest a few limited areas were still dry, but, in general, the drought was largely relieved.

Small grains.—During the first two decades there was little change in the condition of winter wheat in the Southwest, especially in western Texas, Oklahoma, and most of Kansas, with the drought unrelieved and the crop deteriorating in many parts. Condition of wheat was very spotted in this area, ranging from very poor to only fair, although in some sections of Kansas the crop was holding up well, with jointing reported from the Southeast. Outside of this droughty region winter wheat progress and condition varied widely, with good advance in the northwestern parts of the belt, but slow growth in the Ohio Valley, although rains were helpful in the latter area. During the last decade the drought in the Southwest was generally broken, with heavy rains over practically all parts of Oklahoma and beneficial falls in Texas and Kansas. Parts of southwestern Kansas still needed moisture, but much of the wheat crop revived and showed marked improvement. Except for some need of rain over central and eastern parts of the Winter Wheat Belt, the crop was making satisfactory advance at the close of the month.

The condition of oats closely paralleled that of winter wheat, while spring oat and barley seeding had been largely finished at the close of the month. Spring-wheat seeding was mostly completed, with much up and looking well, while other small-grain crops were making satisfactory progress.

Corn.—While moderately warm and mostly sunny weather was favorable for field operations in the Corn Belt during the first decade, frequent showers and low temperatures caused considerable delay to planting and preparations during the latter part of the month. Seed beds had been prepared in Iowa, but only a small amount of corn had been planted, while the early-planted crop was not coming up.

Cotton.—During the first decade cotton planting made good advance in Texas, but warm rains were needed for germination; in Oklahoma seed beds had been prepared, but the drought delayed planting. In central and eastern parts of the belt planting made good headway, except in the extreme Southeast, where it was too wet. During the second decade continued dry soil in the western Cotton Belt further delayed planting, although some was put in western Texas, where germination was hindered by dry soil and low temperatures. The soil continued too dry for germination in Oklahoma, but in central parts of the belt field work made rather good progress, while planting was active in more eastern portions. Rainfall during the last decade in the western Cotton Belt decidedly improved the condition of the soil, but the central and some eastern parts were beginning to need rain. Planting continued in Texas, while seeding operations in Oklahoma were only awaiting drier soil. A good, general warm rain was needed in central and some eastern parts of the belt.

Miscellaneous crops.—Except for droughty conditions in the Southwest, range and livestock conditions were largely satisfactory throughout the country during the month, although the low temperatures retarded growth of pastures in the East. Lambing was favored quite generally, while shearing advanced satisfactorily.

During the first two decades potatoes and truck crops did well, with planting of the former advancing to the northern portions of the country. The frost during the last decade caused some injury to potatoes and truck in the Ohio Valley and adjacent sections, but elsewhere these crops did well. There was rather extensive frost injury to fruit reported over a wide area embracing the Appalachian Mountain districts, the Ohio Valley, the Lake region, and the Northeast, although later reports indicated that the early fears were rather pessimistic, especially in the central Appalachian area. Outside of these sections, fruit did well, except for some local dropping.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The weather over the North Atlantic during April was marked by few unusual features, and the number of days with gales was not far from the normal over the greater part of the ocean. As shown by Table 1, the monthly pressure departures were comparatively small, and, with the exception of Horta, the range in barometric readings not unusually large.

The number of days in which fog was reported in different localities was as follows: Over the Grand Banks on 13 days; along the American coast between the thirty-fifth and forty-fifth parallels, from 7 to 10 days; in the Gulf of Mexico, from 1 to 4 days; over the steamer lanes, east of the forty-fifth meridian, on from 1 to 4 days.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian). North Atlantic Ocean, April, 1930*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Isle, Newfoundland	29.86	+[1] 0.03	30.24	19th	29.38	4th.
Halifax, Nova Scotia	29.94	+[2] 0.01	30.56	15th	29.28	3d.
Nantucket	30.01	+[2] 0.04	30.60	17th	29.26	7th.
Hatteras	30.07	+[2] 0.04	30.42	10th	29.62	7th.
Key West	30.01	−[2] 0.02	30.22	11th	29.84	25th.
New Orleans	30.06	+[2] 0.02	30.34	10th	29.90	3d.
Cape Gracias, Nicaragua	29.91	−[1] 0.06	29.98	2d [3]	29.80	30th.
Turks Island	30.08	+[1] 0.06	30.18	12th	29.96	24th.[3]
Bermuda	30.11	+[2] 0.02	30.28	6th[3]	29.68	4th.
Horta, Azores	30.17	+[1] 0.06	30.62	9th	29.04	21st.
Lerwick, Shetland Islands	29.89	+[1] 0.09	30.37	27th	29.21	13th.
Valencia, Ireland	29.85	−[1] 0.04	30.30	16th	29.04	1st.
London	29.87	−[1] 0.07	30.23	8th	29.42	3d.

[1] From normals shown on Hydrographic Office Pilot Charts, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian time.
[2] From normals based on 8 a. m. observations.
[3] And on other date or dates.

Results at Julianehaab, Greenland, are not given, as reports were received from that station for only 13 days of the month.

The disturbance that on March 31 was over the middle and eastern sections of the steamer lanes on April 1 was central near 50° N., 20° W. While the storm area had contracted somewhat in extent, wind of force 7 to 10 still prevailed east of the thirty-fifth meridian. On the 2d this LOW was central near 55° N., 15° W., and while low barometric readings were still reported from vessels near the center the force of the wind had decreased considerably in intensity, few gales being reported from that section of the ocean.

On the 3d the coast of southern Europe was swept by moderate to whole gales, the storm area extending as far west as the fifteenth meridian.

On the 2d and 3d a depression central over the Maritime Provinces was responsible for westerly gales in the southerly quadrants.

Charts VIII to XI cover the period from the 4th to 7th, inclusive, and Chart XI gives an idea of the unusual conditions that prevailed on the 7th, when westerly gales occurred over the northern quadrant of the North Atlantic HIGH, accompanied by comparatively high barometric readings.

From the 8th to 20th there ensued a period of comparative inactivity over the ocean as a whole, although a number of vessels in widely scattered localities encountered gales, as shown by reports in table. On the 11th the Danish steamship *Viborg* reported a westerly gale in the Gulf of Mexico, as shown in table, and on the 15th northerly gales were also reported from the vicinity of the Straits of Gibraltar.

On the 17th the North Atlantic HIGH was unusually well developed, and anticyclonic conditions also prevailed over northern New England, with a barometric reading of 30.70 at Portland, Me.

On the 21st the region usually occupied by the North Atlantic HIGH was covered by an area of low pressure, central near Horta, where the barometer read 29.04 inches; this LOW was accompanied on the 21st and also 22d by moderate to strong gales between the thirty-fifth and fiftieth parallels.

From the 23d to 28th moderate weather was the rule, with the exception of moderate disturbances on the 23d and 28th, the former being central about 300 miles north of the Madeiras and the latter about 500 miles north of the Azores.

On the 29th a LOW was central near 47° N., 48° W., that increased rapidly in intensity as it moved eastward, and on the 30th, when the center was near 50° N., 42° W., moderate to strong westerly gales prevailed over the steamer lanes between the thirtieth and forty-fifth meridians.

OCEAN GALES AND STORMS, APRIL, 1930

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Tankschindler, Ger. S. S.	Curacao	Ardrossan	48 54 N	21 29 W	Mar. 30	8 a, 1	Apr. 1	28.35	WSW.	WSW, 10.	W.	WSW, 10.	Steady.
Steel Traveler, Am. S. S.	Gibraltar	New York	35 45 N	29 04 W	Apr. 1	10 p, 1	Apr. 2	29.58	SW.	W, 9.	NW.	W, 9.	SW-W-NW.
Extavia, Am. S. S.	Palermo	do	39 06 N	68 00 W	Apr. 2	7 p, 2	Apr. 3	29.62	W.		NW.	WNW, 10.	
Ampetco, Belg. M. S.	Antwerp	Baton Rouge	44 17 N	14 00 W	do	6 p, 2	do	28.72	SE.	NW, 11.	WNW.	NW, 11.	
Atlanta City, Am. S. S.	Port Said	Charleston	35 26 N	20 03 W	Apr. 1	5 a, 2	do	29.72	WSW.	SW, 9.	NW.	SW, 10.	W-WSW.
West Elcasco, Am. S. S.	Houston	Venice	38 55 N	55 41 W	Apr. 2	2 a, 3	do	29.68	S.	ESE, 8.	W.	S, 10.	
Haarlem, Du. S. S.	Amsterdam	Curacao	45 23 N	9 20 W	do	3 a, 3	do	28.79	ESE.	SW, 11.	WNW.	WNW, 12.	SW-W-WNW.
Novian, Br. S. S.	Liverpool	Boston	41 50 N	60 01 W	Apr. 4	6 p, 4	Apr. 5	28.48	E.	N, —.	WNW.	N, 12.	SE-E-N.
America, Am. S. S.	Cobh	New York	41 44 N	59 26 W	do	7 p, 4	do	28.41	S.	SW, 8.	NNW.	NNW, 12.	SW-N-NNW.
Cingalese Prince, Br. M. S.	Port Said	Boston	41 06 N	52 22 W	Apr. 3	4 a, 5	do	29.09	WSW.	SSW, 10.	WNW.	SW, 12.	SSW-W-NNW.
Bellepline, Am. S. S.	Antwerp	New York	45 58 N	39 12 W	Apr. 5	11 p, 5	Apr. 7	29.40	S.	WSW, 9.	N.	WSW, 11.	SW-WSW.
West Harcuvar, Am. S. S.	Bremen	Boston	43 45 N	40 25 W	do	4 a, 6	Apr. 6	29.60	WSW.	W, 10.	WNW.	W, 10.	
New Brighton, Br. S. S.	Africa	Philadelphia	34 45 N	67 15 W	Apr. 6	8 a, 7	Apr. 9	29.79	SE.	SW, 10.	NW.	—, 12.	SE-S-W-NW.
Exilona, Am. S. S.	New York	Piraeus	40 15 N	66 21 W	do	Noon, 7	Apr. 7	29.62	S.	S, —.	SSW.	S, 11.	S-SSW.
Tomalva, Am. S. S.	Newport News.	Rotterdam	44 52 N	37 23 W	Apr. 4	10 a, 7	do	29.64		S, 6.	W.	—, 11.	S-SW-WNW.
Examelia, Am. S. S.	Gibraltar	New York	37 08 N	52 00 W	Apr. 9	4 p, 9	Apr. 10		S.	S, 7.	SW.	S, 9.	S-SW-W.
Viborg, Dan. S. S.	New Orleans	Port Limon	24 18 N	86 08 W	Apr. 11	10 a, 11	Apr. 12	30.07	ENE.	ENE, 8.	E.	ENE, 9.	Steady.
West Elcasco, Am. S. S.	Houston	Venice	38 35 N	15 43 W	Apr. 10	4 p, 11	do	29.84	NNW.	NNW, 9.	N.	NNW, 9.	NNW-NNE.
Julius Schindler, Ger. S.	Hamburg	Curacao	32 38 N	41 45 W	Apr. 11	6 a, 12	do	29.88	ESE.	SE, 10.	SSW.	SSE, 11.	ESE-SSW.
Burgerdijk, Du. S. S.	Norfolk	Rotterdam	42 37 N	42 00 W	Apr. 17	4 p, 17	Apr. 17	29.82	SSE.	SSW, 9.	NW.	SSW, 9.	SSW-NW.
West Keene, Am. S. S.	Gibraltar	New York	34 47 N	27 21 W	Apr. 20	3 p, 21	Apr. 22	28.71	SW.	SW, —.	W.	—, 12.	SW-NW.
Sarcoxie, Am. S. S.	Havre	do	42 33 N	50 10 W	Apr. 21	8 a, 21	do	29.64	W.	W, 3.	W.	W, 9.	Steady.
Yaka, Am. S. S.	Gibraltar	Boston	36 13 N	15 24 W	do	3 a, 23	Apr. 23	28.97	SSW.	SW, 12.	NW.	SW, 12.	SSW-SW.
Exton, Am. S. S.	Palermo	New York	37 00 N	1 00 W	Apr. 28	4 a, 29	Apr. 30	29.63	WSW.	WSW, 9.	SW.	SW, 9.	WSW-SW.
New York, Ger. S. S.	Hamburg	do	44 40 N	39 00 W	Apr. 29	Mdt, 29	do	29.33	SE.	SW, 9.	NW.	W, 10.	SW-W.
Volendam, Du. S. S.	Rotterdam	do	45 56 N	35 25 W	Apr. 30	4 p, 30	May 1	29.34	SSE.	SW, 9.	W.	W, 10.	WSW-W.

Ocean gales and storms, April, 1930—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH PACIFIC OCEAN			° ′	° ′				*Inches*					
Patrick Henry, Am. S. S.	Formosa	Honolulu	26 00 N	178 40 E	Mar. 30	4 p, 1	Apr. 1	30.04	ENE	NNE, 8	NNE	NE, 9	Steady.
Emp. of Canada, Br. S. S.	Yokihama	Vancouver	50 34 N	148 54 W	do	8 p, 2	Apr. 2	29.35	W	W, 7	W	NW, 9	WSW-NNW.
Radnor, Am. S. S.	do	San Pedro	35 07 N	143 21 E	do	10 a, 3	Apr. 3	29.43	NE	S, 4	NW	NE, 11	SE-NE-NW.
Tamaha, Br. S. S.	San Pedro	Yokohama	33 55 N	141 30 E	Apr. 2	10 a, 2	do	29.45	ENE	ENE, 11	NW	NNE, 12	NE-N.
Petricola, Br. S. S.	Singapore	do	33 02 N	136 57 E	do	8 a, 2	do	29.90	ENE	NE, 9	NW	NE, 9	Steady.
Stuart Dollar, Am. S. S.	Nagoya	Los Angeles	35 03 N	142 05 E	do	2 a, 3	Apr. 4	29.56	NE	NE, 11	NW	NE, 12	NE-NNE.
Hamburg Maru, Jap. S. S.	Kobe	San Francisco	40 27 N	151 59 E	do	4 a, 4	do	29.69	ENE	SSE, 8	S	SSE, 9	SSE-S.
Pres. Lincoln, Am. S. S.	Seattle	Yokohama	37 05 N	143 00 E	Apr. 3	Noon, 3	Apr. 3	29.69	NE	N, 9	NNW	N, 10	NE-N-NNW.
Akagisan Maru, Jap. M. S.	Yokohama	San Francisco	43 12 N	141 00 W	do	8 p, 3	do	29.11	S	S, 9	S	S, 10	Steady.
Pennsylvania, Am. S. S.	Portland	Yokohama	43 39 N	152 15 E	do	Noon, 4	Apr. 4	29.56	WSW	S, 7	WSW	W, 9	SE-S-SW.
Mayebashi Maru, Jap. S. S.	Yokohama	San Francisco	39 00 N	148 00 E	Apr. 9	6 p, 9	Apr. 10	29.17	W	WNW, 8	NW	NW, 9	2 pts.
Yomachichi, Am. M. S.	Hong Kong	San Pedro	36 10 N	152 40 E	do	10 p, 9	Apr. 11	29.61	SSW	WNW, 8	NNW	NW, 9	SSW-W-WNW.
Do.	do	do	38 50 N	158 10 W	Apr. 15	4 a, 18	Apr. 19	29.95	NW	NNW, 9	N	NNW, 9	NW-NNW-N.
Tamaha, Br. S. S.	Yokohama	do	38 32 N	157 35 E	Apr. 10	7 a, 10	Apr. 11	29.05	SW	WSW, 9	NW	WNW, 11	WSW-W-WNW.
Wilhlemina, Am. S. S.	Seattle	Honolulu	42 20 N	136 27 W	Apr. 13	2 a, 13	Apr. 15	29.51	NW	NW, 8	SW	SSE, 9	N-NW.
Mishima Maru, Jap. S. S.	Yokohama	Victoria	35 09 N	140 43 E	Apr. 15	Mdt, 15	Apr. 16	29.50	NNE	NNW, 9	NW	NNW, 9	NNE-N-NNW.
Stanley Dollar, Am. S. S.	Sagay	Los Angeles	39 27 N	166 00 E	Apr. 16	2 p, 17	Apr. 18	29.38	E	SW, 8	W	W, 9	S-SW-WSW.
Frank G. Drum, Am. S. S.	Yokohama	San Francisco	45 20 N	169 30 E	do	5 a, 18	Apr. 19	28.76	SE	SW, 9	W	SW, 10	S-SW.
Aden Maru, Jap. S. S.	Iloilo	San Pedro	41 10 N	169 10 E	do	5 p, 17	do	28.99	E	SSW, 8	WSW	W, 9	S-SSW.
Olympia, Am. S. S.	Tacoma	Yokohama	48 45 N	170 30 E	Apr. 17	6 a, 21	Apr. 21	28.84	SE	ESE, 6	ESE	ESE, 9	ESE-SSE.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The average atmospheric pressure over the Aleutian Islands and the Gulf of Alaska for April continued with little change from that of March. The center of the Aleutian cyclone remained in the neighborhood of Kodiak, where the pressure was 29.72 inches, but over a considerable region which extended well into the Bering Sea, the average reading was below 29.80 inches. At the beginning of the month the Aleutian cyclone was rather deep and energetic over the Gulf of Alaska, the minimum barometer readings at stations along the coast from Kodiak to Juneau being close to 29 inches—slightly lower at Kodiak—on the 2d. After the decadence of this manifestation of the semipermanent northern cyclone on the 6th, no other deep depression appeared in the north until the 28th, when pressures dropped to 28.38 and 28.40 inches, at Dutch Harbor and St. Paul, respectively. This intensified cyclone lost energy rapidly, however, and entered Alaska on the 30th as a shallow depression.

The California-Pacific anticyclone reached its highest and steadiest development in the general neighborhood of Midway Island, where it was practically unbroken by intruding Lows. Between the Hawaiian Islands and the American mainland it occupied most of the middle latitudes, but was disrupted on several days by depressions of moderate energy, though of considerable size.

Barometric data for several island and coast stations in west longitudes, including Point Barrow on the Arctic Ocean, are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean and adjacent waters, April, 1930*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1]	30.13		30.54	23d	29.68	29th.
Dutch Harbor [1 2]	29.81	−0.02	30.22	17th	28.38	28th.
St. Paul [1]	29.76	−0.04	30.26	17th	28.40	28th.
Kodiak [1]	29.72	−0.08	30.28	12th	28.86	2d.
Midway Island [1]	30.17	+0.07	30.32	2d	29.96	26th.
Honolulu [3]	30.06	0.00	30.17	28th	29.92	21st.
Juneau [3]	29.87	−0.09	30.30	10th	29.13	2d.
Tatoosh Island [3 4]	29.98	−0.06	30.26	10th	29.59	27th.
San Francisco [3 4]	30.02	−0.02	30.27	4th	29.66	30th.
San Diego [3 4]	29.97	+0.01	30.17	3d	29.77	30th.

[1] P. m. observations only.
[2] For 29 days.
[3] A. m. and p. m. observations.
[4] Corrected to 24-hour mean.

After the considerable storminess occurring over the ocean during the preceding six months, April saw the North Pacific comparatively free from tempestuous winds. The majority of gales reported by our observers did not exceed force 9 on the Beaufort scale. Of the few more violent gales—forces 11 and 12—the most important resulted from a typhoon which passed the southeast coast of Hondo during the 2d and 3d of the month. At this time, although winds of hurricane force were experienced by vessels 100 miles or less south and east of Yokohama, no pressures lower than 29.43 inches were reported as read. This cyclone appeared as a depression between southern Japan and the Ogasawara Islands at the end of March, but did not become severe

until April 2. On the 4th it progressed rapidly toward the Kuril Islands, on the way causing fresh to strong gales east of Yezo, and was central somewhere south of Kamchatka on the 5th.

The only other known typhoon of the month was a small but violent storm which crossed the Philippines on the 18th–19th. The Bureau has no vessel weather report of this disturbance, but its history is given in the subjoined article by the Rev. José Coronas, S. J., of the Philippine Weather Bureau.

A weak depression, which seems to have formed south of Japan about the 8th, moved northeastward and had gained some considerable energy by the 10th. On this date, in about 38° N., 157° E., the British tanker *Tamaha* encountered the cyclone as a whole gale. Violent winds, up to force 11, were experienced until the morning of the 11th, when the storm abated. The *Tamaha's* lowest barometer was 29.05 inches.

Except in connection with the fluctuating disturbances peculiar to the Aleutian region, there seem to have been no other cyclones of importance west of the one hundred and eightieth meridian. Gales, however, were more frequent along the northern routes west of this meridian than east of it. From Japan eastward to about 160° E. most gales occurred during the first decade of the month, with a scattering few in the third. Between 160° E. and 180° the great majority were a product of the second decade.

In west longitudes no gales of force exceeding 10 have as yet reported. The early disturbance in the Gulf of Alaska, already referred to, created some rough weather north of the fortieth parallel on the 1st to 4th, the worst evidently occurring on the 4th, when a whole gale was encountered near 45° N., 140° W. On this date also Tatoosh Island, then on the extreme eastern edge of the huge cyclone, had a maximum wind velocity of 58 miles an hour (force 10) from the south.

On the 10th a depression formed in about 20° N., 132° W. and began working northward across the California-Hawaiian routes. By night of the 12th it lay off the coast between northern California and British Columbia, and by morning of the 15th had practically disappeared from the ocean area. It caused some squally weather and moderate gales during its northward passage, with a maximum wind force of 9 from the south-southeast on the 13th, near 34° N., 146° W.

About the 14th a moderate cyclone developed in middle latitudes, central near longitude 155° W. It moved rather slowly eastward and northward, spreading considerably in area for several days. By the 23d it lay principally over the Gulf of Alaska, where it remained as an individual disturbance until the 28th, when it became amalgamated with the intense cyclone then central over the eastern waters of the Bering Sea. During its course it acquired only moderate wind and barometric intensity, although fresh to strong gales were experienced in scattered positions between 30° and 50° N., 130° and 160° W., from the 15th to the 21st.

Few winds of gale force were reported from or near the Tropics. These few include moderate to strong anti-cyclonic gales southwest and south of Midway Island on the 1st and 2d, and northers of force 7–8 over and near the Gulf of Tehuantepec on the 6th and 12th. At Salina Cruz Tehuantepecers exceeding 45 miles an hour (force 8 and upward) were reported as follows: 7th, 60 miles; 8th, 60; 12th, 48.

The prevailing wind direction at Honolulu was from the east, and the maximum velocity was at the rate of 27 miles an hour from the east on the 12th.

Fog generally was more frequent along the upper steamship routes west of longitude 150° W., and along the coast of the United States, than in March. It was reported on 5 to 7 days in the various 5° squares in upper middle longitudes south of the Aleutian Islands; on 7 days between the fortieth parallel and the Kuril Islands; on 6 to 8 days off the California coast; on 4 to 5 days off the Washington and Oregon coasts; and on 3 days near shore at the mouth of the Gulf of California. Elsewhere, north of the thirtieth parallel, scattered fog occurred variously on from 1 to 4 days.

TYPHOONS AND DEPRESSIONS

THE FIRST TYPHOON OVER THE PHILIPPINES IN 1930: APRIL 18 TO 19

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

The first typhoon that visited the Philippines this year was rather of a very small diameter, but very intense while traversing the Visayan Islands. The origin of this small typhoon is not clear up to this time. Its center was situated at 6 a. m. of the 18th about 60 or 70 miles to the northeast of Surigao moving west by north. At about noon of the same day it passed very near to the south of Guiuan, southern coast of Samar, where the barometric minimum 747.50 millimeters (29.43 inches) was recorded at 12.30 p. m. Then it passed at 6.40 p. m. close to the north of Ormoc, northern part of Leyte, causing the barometer to fall to 740.91 millimeters (29.17 inches). During the morning and first hours of the afternoon of April 19 it crossed the northern part of Panay Island near the northern coast, and south of Capiz, where the barometric minimum 748.35 millimeters (29.46 inches) was observed at 10 a. m.; the small typhoon was still intense and continued moving to west by north. From Panay the typhoon took a west-northwest direction, and probably filled up soon over the China Sea about 250 miles to the west of northern Mindoro.

The area of destruction of this typhoon was small, but in this area the damage caused by winds of a gale or hurricane force and by heavy rains was very considerable.

The approximate position of the center at 6 a. m. and 2 p. m. of April 18, 19, and 20 was as follows:

April 18,	6 a. m.	126° 15′ longitude E., 10° 40′ latitude N.
	2 p. m.	125° 10′ longitude E., 10° 55′ latitude N.
April 19,	6 a. m.	122° 50′ longitude E., 11° 15′ latitude N.
	2 p. m.	121° 50′ longitude E., 11° 35′ latitude N.
April 20,	6 a. m.	118° 40′ longitude E., 12° 55′ latitude N.
	2 p. m.	116° 20′ longitude E., 13° 40′ latitude N.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, April, 1930

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	65.5	+2.0	3 stations	90	[2] 16	St. Bernard	29	9	1.47	−2.82	Primrose Farm	3.23	Seven Hills	0.06
Arizona	62.7	+4.0	Parker	108	6	Alpine	11	16	0.43	−0.23	Pinedale	2.03	12 stations	0.00
Arkansas	64.9	+3.5	Harrison	96	10	Calico Rock	27	1	1.41	−3.47	Harrison	4.40	Princeton	0.00
California	56.7	+1.5	Amos	106	7	Gem Lake	7	1	1.57	−0.14	Upper Mattole	7.10	2 stations	0.00
Colorado	49.4	+6.2	2 stations	92	9	Dillon	−1	1	1.07	−0.82	Savage Basin	3.50	Manassa	T.
Florida	70.1	+0.2	Brooksville	93	18	Vernon	36	1	3.50	+0.82	Indiantown	10.09	Cottage Hill	0.61
Georgia	64.9	+1.5	Milledgeville	93	12	Clayton	25	1	3.26	−0.32	Bainbridge	6.77	Tallapoosa	1.30
Idaho	50.9	+5.9	Hazelton	89	21	Obsidian	10	1	1.64	+0.20	Grangeville	3.90	Mountainhome	0.27
Illinois	55.6	+3.2	Henry	96	11	Mount Carroll	18	2	2.68	−0.73	Watseka	4.99	Carmi	0.64
Indiana	54.0	+2.0	Winona Lake	100	12	2 stations	18	[2] 2	2.55	−0.94	Collegeville	5.26	Evans Landing	0.44
Iowa	52.1	+3.2	Clarinda	96	10	Alton	5	1	2.67	−0.29	Oskaloosa	4.59	Charlton	1.05
Kansas	59.1	+5.4	4 stations	98	9	Oberlin	12	1	2.82	+0.23	Oswego	7.77	Hugoton	0.43
Kentucky	58.9	+2.9	Williamstown	94	11	Farmers	21	24	1.31	−2.72	Scott	2.77	Irvington	0.34
Louisiana	69.2	+2.2	3 stations	93	[2] 7	Franklinton	36	1	1.38	−3.32	New Orleans (No. 2)	3.46	Logansport	0.00
Maryland-Delaware	50.6	−1.9	Newburg, Md	93	11	Oakland, Md	18	[2] 1	2.48	−0.88	Laurel, Md	3.79	Annapolis, Md	1.29
Michigan	43.3	+0.5	Monroe	90	11	Seney	−2	2	1.77	−0.73	Eloise	4.65	Muskegon	0.51
Minnesota	45.8	+3.2	Canby	88	9	Itasca State Park	6	1	1.06	−0.97	Rochester	4.17	Little Falls	0.08
Mississippi	66.9	+2.3	2 stations	91	[2] 12	4 stations	36	[2] 8	1.21	−4.18	Duck Hill	3.62	Waynesboro	0.15
Missouri	59.1	+4.0	Clinton	96	11	Tarkio	23	1	2.03	−1.78	Joplin	7.72	Marble Hill	0.22
Montana	49.6	+7.4	Crow Agency	89	7	2 stations	5	1	1.41	+0.24	Roundup	3.77	Bridger	0.13
Nebraska	53.6	+4.6	Culbertson	99	8	Gordon	5	1	3.68	+1.23	North Loup	8.29	Paxton	1.33
Nevada	52.5	+4.0	2 stations	100	[2] 6	Rye Patch	11	1	0.84	+0.01	Lamoille	2.48	Mina	0.00
New England	42.4	−1.3	Waterbury, Conn	82	27	Pittsburg (a) N. H.	−2	10	1.64	−1.62	Glencliff, N. H	2.71	Garfield, Vt	0.37
New Jersey	47.6	−1.7	Little Falls	79	14	Belleplain	18	3	2.34	−1.31	Charlotteburg	3.72	Asbury Park	0.50
New Mexico	55.3	+4.6	2 stations	95	[2] 6	2 stations	9	[2] 15	0.59	−0.42	Clovis	2.42	3 stations	0.00
New York	43.1	−1.2	Addison	88	30	do	8	3	2.07	−0.90	High Market	4.05	Chazy	T.
North Carolina	58.7	+1.1	3 stations	98	[2] 12	Mount Mitchell	12	24	2.16	−1.53	Neuse	5.19	Mount Holly	0.51
North Dakota	47.3	+5.6	Carson	86	9	Hansboro	8	1	1.25	−0.13	Carson	3.67	Pembina	0.10
Ohio	52.1	+2.4	Circleville	94	11	Paulding	19	2	2.11	−1.12	Napoleon	4.52	Pleasant Hill	0.59
Oklahoma	65.4	+5.9	Waurika	98	7	Boise City	17	1	2.90	−0.74	Bartlesville	7.31	Goodwell	0.63
Oregon	51.6	+3.8	Echo	90	5	2 stations	10	[2] 1	2.18	−0.07	Willow Creek	6.94	Arlington	0.20
Pennsylvania	48.2	−0.6	Donora	92	11	do	9	[2] 9	2.71	−0.66	Emporium	4.43	Ebensburg	0.66
South Carolina	63.4	+1.1	Society Hill	96	12	Cherokee (near)	28	1	2.16	−0.91	Garnett	7.20	Edgefield	0.55
South Dakota	50.8	+5.4	2 stations	94	9	3 stations	11	1	2.17	0.00	Vivian	4.38	Harveys Ranch	0.40
Tennessee	61.2	+2.5	Clarksville	92	11	2 stations	24	9	1.66	−2.82	Bristol	3.09	Fayetteville	0.62
Texas	70.1	+4.1	2 stations	101	7	Dalhart	24	1	1.95	−1.30	Sinton	13.51	Wiergate	0.00
Utah	52.9	+6.1	St. George	94	[2] 6	2 stations	17	[2] 2	0.92	−0.42	Smithfield	2.48	Leeds (near)	T.
Virginia	54.8	−0.1	Columbia	97	12	Burkes Garden	16	25	2.18	−1.06	Mount Weather	3.98	Stuart	1.01
Washington	51.4	+3.7	Wahluke	89	21	Paradise Inn	16	[2] 2	2.30	−0.24	Wynoochee Oxbow	14.45	2 stations	T.
West Virginia	53.2	+1.6	Moorefield	98	11	Pickens	13	9	1.95	−1.57	Marlinton	4.16	Kermit	0.39
Wisconsin	45.3	+1.9	4 stations	92	[2] 10	Long Lake	7	2	2.00	−0.54	Lancaster	5.20	Neillsville	0.64
Wyoming	47.5	+8.0	Torrington	87	8	Riverside	−4	1	0.86	−0.71	Torrington	3.07	3 stations	T.
Alaska [March]	14.9	−1.9	Tree Point	55	30	Eagle	−49	18	2.83	+1.35	Latouche	16.82	Kasilof	0.08
Hawaii	69.4	−0.8	Kaanapali	89	23	2 stations	48	[2] 1	12.16	+3.01	Kailua (Mauka)	56.00	5 stations	0.00
Porto Rico	76.1	+0.8	Canovanas	98	29	Bayamon	55	14	2.46	−2.23	San Lorenzo (Valdez farm).	6.48	Josefa	0.56

[1] For description of tables and charts, see REVIEW, January, 1930, p. 37.
[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1930*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	°F.		°F.	° F.		°F.	° F.	° F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							43.6	−0.4										66	1.58	−1.5										5.3		
Eastport	76	67	85	29.85	29.94	+0.01	38.8	−0.2	59	14	47	19	17	31	24	34	27	64	1.49	−1.4	10	7,120	s.	40	se.	7	8	5	17	6.5	2.7	0.0
Greenville, Me	1,070	6	----	28.76	29.95	----	35.8	----	65	30	46	8	17	25	39	----	----	----	2.11	----	7	5,206	nw.	32	----	----	2	10	8	12	----	2.3	0.0
Portland, Me	103	82	117	29.87	30.00	+.04	42.3	−0.7	71	14	51	23	24	34	33	37	30	65	1.44	−1.9	5	5,786	nw.	38	se.	7	19	6	5	3.7	T.	0.0
Concord	289	70	79	29.67	29.98	−.01	43.2	−0.2	75	30	56	23	24	31	42	----	----	----	1.29	−1.5	5	4,470	nw.	23	nw.	2	12	13	5	4.4	1.0	0.0
Burlington	403	11	48	29.53	29.98	−.01	40.7	−2.6	71	30	51	20	10	31	37	----	----	----	2.10	0.0	11	6,961	s.	34	s.	1	9	3	18	6.6	4.5	0.0
Northfield	876	12	60	----	30.00	+.01	38.5	−1.8	72	30	51	14	17	26	44	----	----	68	1.69	−0.6	11	4,382	s.	25	sw.	1	6	13	11	6.2	4.8	0.0
Boston	125	106	165	29.86	30.00	+.03	47.6	+1.2	78	14	57	29	24	38	31	40	31	56	2.09	−1.3	6	6,195	nw.	26	s.	7	11	13	6	4.6	T.	0.0
Nantucket	12	14	90	29.99	30.00	+.03	43.8	+0.4	65	14	50	31	24	37	22	40	36	76	1.01	−2.0	9	9,915	sw.	39	se.	7	13	11	6	4.7	T.	0.0
Block Island	26	11	46	29.97	30.00	+.02	44.4	+0.4	66	14	50	31	24	38	22	40	36	76	1.47	−2.1	10	11,391	w.	46	nw.	2	10	11	9	5.3	T.	0.0
Providence	160	215	251	29.83	30.01	+.03	46.8	+0.2	76	14	56	27	24	37	30	39	30	55	1.08	−2.1	9	8,592	nw.	55	se.	7	12	9	9	4.8	T.	0.0
Hartford	159	122	----	29.84	30.02	+.03	46.6	−0.1	76	14	56	27	24	37	29	----	----	----	1.68	−1.7	9	----	nw.	----	----	----	6	12	12	6.4	T.	0.0
New Haven	106	74	153	29.91	30.03	+.04	46.4	−0.8	76	14	55	29	3	38	31	41	36	71	2.09	−1.4	12	6,417	nw.	26	se.	7	8	11	11	5.6	T.	0.0
Middle Atlantic States							50.7	−0.7										66	2.17	−0.9										5.7		
Albany	97	107	115	29.91	30.02	+.02	45.4	−1.4	76	30	55	26	24	36	34	39	32	63	1.53	−0.9	7	5,364	s.	28	se.	1	9	14	7	4.9	0.1	0.0
Binghamton	871	10	84	29.09	30.03	+.01	44.8	−0.6	80	30	55	23	24	35	39	----	----	----	2.30	−0.2	13	4,369	nw.	24	sw.	1	8	7	15	6.3	2.7	0.0
New York	314	414	454	29.69	30.03	+.03	47.6	−1.8	73	14	55	29	24	40	22	41	34	62	2.01	−1.2	11	10,753	nw.	57	w.	7	6	12	12	6.4	T.	0.0
Bellefonte	1,050	5	36	28.91	30.03	----	46.2	----	82	11	58	23	3	34	46	40	35	68	2.72	----	11	----	w.	----	----	----	5	12	13	6.7	0.2	0.0
Harrisburg	374	94	104	29.65	30.06	+.04	49.4	−1.5	74	14	58	30	24	41	29	42	34	60	2.48	−0.2	12	4,914	w.	28	w.	7	7	12	11	6.1	T.	0.0
Philadelphia	114	123	367	29.94	30.06	+.05	51.2	−0.9	74	14	59	33	24	43	26	45	40	70	1.64	−1.4	11	9,174	nw.	40	nw.	2	6	12	12	6.2	T.	0.0
Reading	325	81	98	29.69	30.05	----	49.4	−0.9	74	14	58	29	24	40	31	42	35	62	2.91	−0.4	9	4,673	se.	21	se.	6	7	13	10	6.3	T.	0.0
Scranton	805	111	119	29.16	30.04	+.03	46.4	−1.7	76	30	57	24	23	36	35	40	33	63	2.52	−0.2	12	4,888	sw.	25	sw.	7	5	12	13	6.9	0.7	0.0
Atlantic City	52	37	172	29.99	30.05	+.05	47.8	0.0	67	14	54	32	24	42	23	43	38	72	2.00	−1.0	9	11,729	nw.	60	se.	6	8	16	12	5.5	0.0	0.0
Cape May	17	13	49	----	----	----	48.9	+0.5	74	14	57	31	3	41	26	45	40	75	1.54	−1.4	8	----	nw.	----	----	----	10	10	10	----	T.	0.0
Sandy Hook	22	10	55	30.00	30.02	----	46.9	----	70	14	53	32	24	41	22	41	36	70	2.08	−1.5	11	9,822	nw.	46	sw.	7	6	12	12	6.1	0.0	0.0
Trenton	190	159	183	29.84	30.04	----	48.4	−1.4	72	30	58	29	24	39	29	41	34	62	1.74	−1.2	10	7,426	nw.	42	w.	7	8	9	13	5.8	T.	0.0
Baltimore	123	100	215	29.92	30.05	+.04	52.6	−1.0	79	14	61	34	24	44	31	45	38	62	3.12	−0.2	11	7,390	nw.	48	w.	7	10	11	9	5.4	T.	0.0
Washington	112	62	85	29.93	30.05	+.03	53.2	−0.1	91	11	63	34	24	43	44	45	38	62	3.12	−0.2	6	5,042	nw.	35	nw.	7	10	11	9	5.5	T.	0.0
Cape Henry	18	8	54	30.02	30.04	----	54.6	0.0	89	12	62	38	1	47	39	49	45	75	1.73	−1.6	11	7,697	ne.	39	nw.	9	12	8	10	5.2	0.0	0.0
Lynchburg	681	153	188	29.32	30.06	+.04	56.3	−1.0	92	11	67	29	1	45	40	48	40	60	1.45	−1.5	6	5,170	nw.	32	nw.	7	11	8	11	5.2	0.0	0.0
Norfolk	91	170	205	29.96	30.06	+.05	57.0	+0.2	92	12	66	39	1	48	38	49	43	67	2.38	−0.8	8	7,942	ne.	56	w.	7	11	8	11	5.4	0.0	0.0
Richmond	144	11	52	29.91	30.06	+.04	55.6	−1.0	94	12	67	31	1	44	43	48	41	66	3.19	−0.3	9	4,959	ne.	48	nw.	14	12	11	7	4.8	0.0	0.0
Wytheville	2,304	49	55	27.67	30.04	+.01	53.2	+1.2	85	12	65	26	1	42	41	45	37	60	1.40	−1.6	7	4,538	w.	28	sw.	7	11	13	6	4.3	0.0	0.0
South Atlantic States							63.6	+1.7										66	2.18	−0.8										4.5		
Asheville	2,253	70	84	27.72	30.06	+.03	56.2	+2.3	82	12	67	29	1	45	42	47	40	61	1.72	−1.3	8	5,300	nw.	34	nw.	7	12	12	6	4.3	0.0	0.0
Charlotte	779	55	62	29.21	30.05	+.02	62.2	+2.4	92	12	74	41	24	51	34	51	42	56	0.86	−2.4	6	3,384	sw.	24	nw.	7	15	7	8	4.0	0.0	0.0
Greensboro	886	5	56	29.11	30.07	----	57.2	----	94	12	71	29	1	44	42	49	42	65	1.77	----	6	5,548	ne.	30	nw.	7	10	11	9	5.3	0.0	0.0
Hatteras	11	5	50	30.03	30.04	+.03	60.0	+0.2	85	12	67	41	1	53	26	56	53	80	2.81	−0.7	8	8,253	sw.	48	se.	6	15	10	5	4.1	0.0	0.0
Raleigh	376	103	110	29.65	30.05	+.02	60.6	+1.2	94	12	71	38	24	50	38	51	45	64	2.16	−1.3	8	4,394	ne.	28	nw.	7	12	7	11	4.9	0.0	0.0
Wilmington	78	81	91	29.98	30.06	+.03	63.5	+1.5	92	12	73	41	9	54	33	57	53	75	1.62	−1.0	8	4,762	sw.	29	sw.	7	15	11	4	3.8	0.0	0.0
Charleston	48	11	92	30.01	30.06	+.03	65.6	+1.1	86	12	73	48	1	58	26	59	54	73	2.60	+0.1	4	6,421	sw.	29	e.	5	14	7	9	4.6	0.0	0.0
Columbia, S. C	351	41	57	29.68	30.06	+.03	65.5	+2.2	93	12	76	42	9	55	37	54	46	60	1.64	−1.2	7	4,384	sw.	35	sw.	7	13	13	4	4.2	0.0	0.0
Due West	711	10	55	29.32	30.09	----	62.6	----	89	12	75	41	9	50	35	----	----	----	1.30	----	6	5,726	sw.	42	w.	7	12	10	8	4.5	0.0	0.0
Greenville, S. C	1,039	139	146	28.96	30.05	----	62.9	+4.3	89	12	73	42	1	52	33	52	44	57	2.58	−1.1	7	5,671	ne.	48	w.	7	12	9	9	4.7	0.0	0.0
Augusta	182	62	77	29.85	30.04	+.01	67.0	+2.8	90	12	79	41	1	55	34	56	50	61	1.91	−1.2	5	3,572	nw.	31	w.	7	11	16	3	4.4	0.0	0.0
Savannah	65	150	194	29.99	30.06	+.03	67.1	+1.1	87	23	76	50	9	58	26	58	53	70	4.21	+1.6	6	7,446	e.	30	w.	7	13	8	9	5.0	0.0	0.0
Jacksonville	43	209	245	30.01	30.06	+.02	68.8	+0.1	85	23	76	51	1	61	23	61	56	72	1.86	−0.5	7	7,329	e.	38	sw.	6	9	13	8	5.0	0.0	0.0
Florida Peninsula							73.8	+0.7										76	4.74	+2.6										4.9		
Key West	22	10	64	29.98	30.00	−.02	76.0	+0.3	85	28	81	64	1	71	14	70	68	78	4.39	+3.1	7	6,181	se.	26	s.	24	14	9	7	4.5	0.0	0.0
Miami	25	124	168	30.00	30.03	−.01	73.9	+1.1	84	4	79	58	1	68	21	68	64	75	5.98	+2.9	11	6,722	e.	27	e.	30	8	10	12	5.8	0.0	0.0
Tampa	35	79	197	30.00	30.04	−.02	71.5	+0.6	88	18	80	50	1	63	26	64	61	76	3.84	+1.8	5	7,394	e.	35	se.	29	10	9	11	5.3	0.0	0.0
Titusville	44	5	----	30.00	30.05	----	71.8	----	91	23	81	53	9	62	30	----	----	----	3.99	----	9	----	ne.	----	----	----	15	9	6	3.9	0.0	0.0
East Gulf States							66.9	+2.2										63	1.99	−2.2										4.3		
Atlanta	1,173	190	216	28.82	30.06	+.03	63.4	+2.4	85	12	73	45	9	54	28	52	43	54	1.40	−2.2	6	7,052	nw.	43	nw.	7	9	12	9	5.1	0.0	0.0
Macon	370	78	87	29.67	30.06	+.03	64.9	+1.0	88	12	77	40	1	53	35	55	47	57	4.19	+1.0	7	3,743	nw.	23	n.	7	12	9	9	5.0	0.0	0.0
Thomasville	273	49	103	29.76	30.06	+.03	67.6	+0.9	86	17	78	47	1	57	29	58	53	66	4.49	+1.2	7	4,782	e.	24	sw.	7	9	10	11	5.3	0.0	0.0
Apalachicola	56	11	51	30.02	30.06	----	67.4	----	84	23	74	48	1	61	20	62	59	76	2.00	−0.8	5	5,431	e.	28	e.	29	13	11	6	4.0	0.0	0.0
Pensacola	56	149	185	30.00	30.06	+.04	67.9	+1.2	79	19	73	57	1	63	16	61	56	73	0.89	−3.1	5	7,377	s.	27	e.	30	11	12	7	4.5	0.0	0.0
Anniston	741	9	57	29.30	30.09	+.06	63.3	+2.9	86	15	77	36	25	50	40	----	----	----	1.54	−2.8	5	3,080	s.	20	w.	7	15	10	5	3.9	0.0	0.0
Birmingham	700	11	48	29.31	30.07	+.05	66.0	+2.7	85	21	78	41	25	54	35	53	44	54	1.38	−3.4	3	4,173	s.	25	w.	7	14	9	7	4.0	0.0	0.0
Mobile	57	125	161	30.00	30.06	+.04	68.8	+2.5	87	22	78	51	25	60	28	60	55	71	0.77	−3.9	6	5,965	s.	25	nw.	6	14	8	8	4.7	0.0	0.0
Montgomery	223	100	112	29.82	30.07	+.04	67.8	+2.5	86	23	78	47	25	57	31	56	48	55	2.26	−2.0	3	3,990	sw.	20	w.	7	14	10	6	4.1	0.0	0.0
Corinth	469	6	----	----	----	----	65.5	----	89	12	79	36	9	52	46	----	----	----	1.30	----	4	----	s.	----	----	----	9	20	1	----	0.0	0.0
Meridian	375	87	95	29.66	30.05	+.03	66.6	+2.6	86	21	78	44	25	55	34	55	47	57	1.86	−2.9	4	3,406	ne.	20	w.	7	15	9	6	3.9	0.0	0.0
Vicksburg	247	65	73	29.78	30.06	+.06	68.7	+3.1	86	7	79	48	1	58	29	57	49	58	0.20	−5.0	5	4,455	se.	21	nw.	6	15	9	6	3.8	0.0	0.0
New Orleans	53	76	84	30.00	30.05	+.05	70.8	+2.0	86	7	79	52	1	62	25	63	59	74	2.89	−2.4	6	4,104	se.	17	nw.	6	15	11	4	3.6	0.0	0.0
West Gulf States							70.1	+3.6										67	1.60	−2.1										4.5		
Shreveport	249	77	93	29.74	30.01	+.04	71.0	+5.2	93	7	82	54	24	60	32	59	52	59	0.75	−3.9	6	4,014	se.	19	se.	4	13	13	4	3.9	0.0	0.0
Bentonville	1,303	11	44	28.62	29.98	+.02	62.5	+5.6	87	10	73	40	8	52	37	----	----	----	2.46	----	13	4,167	s.	20	s.	1	21	1	8	----	0.0	0.0
Fort Smith	457	79	94	29.50	29.98	+.02	66.4	+4.6	90	10	77	49	26	56	32	----	----	58	1.85	−2.1	9	5,098	e.	30	e.	26	10	10	10	----	0.0	0.0
Little Rock	357	136	153	29.65	30.02	+.04	66.4	+4.3	90	10	77	45	23	56	31	55	46	54	0.17	−5.0	4	5,441	s.	22	s.	29	10	9	11	5.4	0.0	0.0
Austin	605	136	148	29.33	29.96	----	71.6	+3.8	92	7	84	51	4	60	41	61	55	65	0.74	−3.6	5	5,368	se.	39	w.	28	10	11	9	4.8	0.0	0.0
Brownsville	57	83	100	29.90	29.96	----	73.8	+0.1	93	5	82	56	5	65	37	67	64	82	3.09	+1.7	3	7,226	se.	26	se.	1	8	15	7	5.0	0.0	0.0
Corpus Christi	20	11	78	29.96	29.98	+.03	71.9	+1.1	90	5	78	55	4	66	34	67	65	84	1.53	−0.2	10	7,952	se.	40	se.	28	8	12	10	5.0	0.0	0.0
Dallas	512	220	227	29.43	29.97	----	70.6	----	95	7	81	54	3	60	32	----	----	----	1.61	−2.6	5	8,477	se.	45	ne.	26	22	5	3	3.0	0.0	0.0
Fort Worth	670	106	114	29.24	29.94	+.01	71.1	+6.1	97	7	83	51	4	60	38	59	51	57	2.37	−1.6	5	6,608	s.	28	se.	15	10	12	8	5.2	0.0	0.0
Galveston	54	106	114	29.98	30.04	+.07	70.9	+2.2	86	7	76	62	4	66	22	65	62	81	3.99	+0.9	5	6,829	se.	30	w.	3	14	10	6	4.2	0.0	0.0
Groesbeck	461	11	56	29.50	29.98	----	70.0	----	91	7	81	53	6	59	37	----	----	----	2.09	−2.5	6	7,307	s.	30	w.	29	13	11	6	4.2	0.0	0.0
Houston	138	292	314	29.87	30.02	----	71.8	+2.5	90	7	81	60	29	63	28	----	----	----	0.93	−2.6	7	8,123	se.	48	se.	29	12	11	7	4.1	0.0	0.0
Palestine	510	64	72	29.47	30.00	+.04	70.8	+4.8	93	7	82	56	10	60	32	60	53	63	0.99	−3.4	7	4,839	s.	20	s.	27	13	9	8	4.2	0.0	0.0
Port Arthur	34	58	66	29.99	30.03	----	71.8	----	90	7	80	59	7	64	31	----	----	----	1.31	−1.7	5	4,497	se.	19	n.	6	16	8	6	3.7	0.0	0.0
San Antonio	693	119	132	29.24	29.96	+.03	72.2	+3.1	93	7	83	50	4	62	34	62	57	66	2.20	−1.0	6	4,627	se.	29	e.	28	10	9	11	5.4	0.0	0.0
Taylor	571	55	63	29.40	30.00	+.05	70.8	+3.3	93	7	83	51	4	59	38	----	----	----	0.43	−3.3	2	5,683	s.	26	sw.	25	16	8	6	2.9	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1930*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*°F.*		*°F.*			*°F.*	*° F.*	*° F.*	*° F.*	*N*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							57.7	+2.9										58	1.88	−1.8										5.0		
Chattanooga	762	190	215	29.24	30.06	+0.03	63.2	+2.9	86	12	74	40	1	52	35	51	41	49	1.46	−3.4	3	5,446	sw.	34	nw.	7	10	13	7	4.7	0.0	0.0
Knoxville	995	102	111	29.00	30.06	+.03	61.4	+3.4	87	12	73	36	1	50	37	51	43	56	1.39	−2.8	7	4,133	sw.	28	sw.	7	8	18	4	4.5	0.0	0.0
Memphis	399	76	97	29.62	30.04	+.04	65.8	+4.0	85	10	74	45	25	57	27	54	46	54	1.45	−3.3	5	4,629	sw.	24	sw.	1	16	3	11	4.6	0.0	0.0
Nashville	546	168	191	29.49	30.08	+.07	62.0	+3.0	87	11	72	38	24	52	32	52	43	55	1.16	−3.0	6	5,891	s.	31	nw.	7	11	11	8	4.7	0.0	0.0
Lexington	989	193	230	29.01	30.08	+.06	57.6	+3.3	85	11	68	32	25	48	27				0.81	−2.7	11	8,646	s.	37	nw.	13	15	13	2	3.3	0.0	0.0
Louisville	525	188	234	29.48	30.07	+.06	59.5	+3.1	89	11	70	36	25	49	35	49	41	56	0.64	−3.2	8	7,017	sw.	36	nw.	7	11	14	5	4.3	0.0	0.0
Evansville	431	76	116	29.58	30.05	+.05	59.8	+3.1	88	11	69	38	25	50	30	50	42	56	1.10	−2.8	7	5,797	s.	26	s.	15	10	8	12	5.3	0.0	0.0
Indianapolis	822	194	230	29.15	30.04	+.04	55.1	+3.0	89	11	65	32	8	45	36	46	38	58	4.05	+0.4	11	7,298	nw.	34	nw.	7	11	10	9	5.0	0.0	0.0
Royal Center	736	11	55	29.24	30.04		50.4		90	11	62	25	2	39	40				3.86	+0.8	12	7,386	e.	37	nw.	7	7	12	11	5.8	0.0	0.0
Terre Haute	575	96	129	29.41	30.03		57.2		91	11	67	30	2	47	34	48	41	61	2.12	−1.5	10	5,887	s.	31	s.	29	12	10	8	4.7	0.0	0.0
Cincinnati	627	11	51	29.37	30.05	+.04	56.6	+4.2	90	11	68	31	25	45	36	47	39	59	2.05	−1.1	10	4,894	sw.	30	sw.	1	10	12	8	4.9	0.0	0.0
Columbus	822	179	222	29.16	30.05	+.03	54.2	+3.0	88	11	64	28	24	44	36	46	39	62	1.28	−1.6	11	6,997	nw.	40	nw.	7	9	12	9	5.2	T.	0.0
Dayton	899	137	173	29.08	30.04		54.8	+3.2	88	11	65	31	24	45	33	46	39	61	1.54	−1.7	11	5,856	sw.	29	nw.	7	9	13	8	5.0	T.	0.0
Elkins	1,947	59	67	28.00	30.06	+.03	50.1	+1.3	82	12	62	22	24	38	46	43	36	65	3.16	−0.5	13	4,327	w.	28	w.	7	6	13	11	6.5	3.7	0.0
Parkersburg	637	77	82	29.40	30.06	+.03	56.0	+2.6	88	12	67	30	9	45	42	46	38	58	1.45	−1.7	11	4,057	nw.	30	nw.	7	12	5	13	5.6	T.	0.0
Pittsburgh	842	353	410	29.13	30.04	+.02	51.5	+0.3	86	11	61	26	24	42	36	44	38	65	2.60	−0.3	13	7,086	nw.	40	w.	1	9	6	15	6.1	1.0	0.0
Lower Lake Region							45.3	−0.1										70	2.35	−0.2									6.3		
Buffalo	767	247	280	29.17	30.02	+.01	41.4	−1.4	72	29	50	23	23	33	32	37	32	72	1.29	−1.3	11	10,159	w.	42	sw.	1	9	7	14	6.1	3.9	0.0
Canton	448	10	61	29.50	29.98		40.1	−2.4	74	30	50	18	23	30	35				2.18	0.0	12	6,212	sw.	38	sw.	1	4	15	11	6.4	4.7	0.0
Ithaca	836	5	100	29.10	30.04	+.02	43.0	−2.0	78	30	53	23	23	33	39	38	33	70	2.46	0.0	12	7,070	nw.	30	s.	6	6	4	20	7.4	4.7	0.0
Oswego	335	76	91	29.64	30.02	+.01	41.8	−1.8	68	30	49	24	23	35	27	38	33	73	2.02	−0.3	12	6,834	w.	24	nw.	23	6	8	16	6.7	0.1	0.0
Rochester	523	86	102	29.45	30.04	+.03	43.8	−1.1	75	30	52	24	23	35	29	38	31	63	1.51	−0.8	14	6,015	w.	25	w.	7	7	9	14	6.4	2.3	0.0
Syracuse	596	65	79	29.37	30.02	+.01	45.0	+0.6	78	30	53	23	23	37	33				2.43	0.0	12	5,022	w.	21	w.	23	8	7	15	6.4	4.4	0.0
Erie	714	130	166	29.25	30.03	+.01	45.0	−0.1	74	10	53	27	23	37	36	41	37	75	2.83	+0.1	15	8,790	w.	44	se.	17	10	10	10	5.7	4.9	0.0
Cleveland	762	267	337	29.20	30.03	+.01	48.3	+2.1	82	11	57	28	24	40	36	42	36	67	2.08	−0.4	9	9,162	w.	44	w.	8	8	9	13	6.1	T.	0.0
Sandusky	629	5	67	29.35	30.04	+.02	48.3	+1.1	84	11	57	28	23	39	38				2.70	+0.2	11	6,432	ne.	32	nw.	7	6	10	14	6.2	T.	0.0
Toledo	628	208	243	29.35	30.04	+.03	48.8	+1.2	87	11	58	29	24	39	39	42	37	68	2.86	+0.2	11	8,526	nw.	39	w.	18	11	7	12	5.4	T.	0.0
Fort Wayne	856	113	124	29.10	30.04		50.6	+1.3	90	11	60	27	24	41	37	43	37	66	2.27	−0.8	13	5,748	nw.	32	nw.	7	6	8	16	6.4	T.	0.0
Detroit	730	218	258	29.24	30.04	+.02	47.6	+1.4	86	11	57	27	23	38	40	42	39	78	3.60	+1.1	12	6,494	e.	37	sw.	18	5	16	9	6.2	0.4	0.0
Upper Lake Region							42.6	+1.1										70	1.92	−0.6									5.3		
Alpena	609	13	92	29.37	30.04	+.02	38.0	−0.6	63	13	45	20	2	31	27	34	29	73	2.08	−0.2	11	7,901	nw.	42	nw.	7	6	12	12	6.3	3.7	0.0
Escanaba	612	54	60	29.38	30.06	+.04	38.2	+0.3	59	13	46	15	2	31	24	34	28	70	1.16	−1.1	8	6,416	s.	40	n.	7	12	10	8	4.6	1.1	0.0
Grand Haven	632	54	89	29.33	30.02	+.01	44.4	+0.7	76	30	52	25	2	36	33	39	34	72	2.34	−0.3	9	7,485	e.	34	nw.	7	11	6	13	5.6	T.	0.0
Grand Rapids	707	70	87	29.27	30.05	+.03	47.6	+0.6	84	10	57	27	23	38	35	40	33	63	2.07	−0.7	10	8,019	n.	38	n.	7	7	10	13	6.1	T.	0.0
Houghton	668	64	99	29.30	30.04	+.02	39.6	+1.9	75	9	49	18	2	30	40				0.97	−1.5	7	6,239	e.	34	w.	21	10	8	12	5.7	0.3	0.0
Lansing	878	6	49	29.08	30.03		45.2	−0.4	80	10	56	25	23	34	39	41	58	78	1.97	−0.6	12	3,974	nw.	22	nw.	7	9	8	13	5.7	0.2	0.0
Ludington	637	60	66	29.33	30.04		43.5	+1.6	75	30	52	23	2	36	31	38	33	71	3.46	+0.9	11	6,610	n.	31	nw.	7	13	12	5	4.5	3.0	0.0
Marquette	734	77	111	29.24	30.05	+.03	40.0	+2.2	79	30	48	22	22	32	31	35	30	69	1.34	−1.1	10	6,639	nw.	35	s.	9	10	6	14	5.9	2.2	0.0
Port Huron	638	70	120	29.32	30.03	+.01	43.2	+0.2	80	30	53	22	22	34	37	38	34	73	1.77	−0.5	10	7,541	nw.	34	n.	8	6	17	7	5.3	0.1	0.0
Sault Sainte Marie	614	11	52	29.34	30.06	+.03	37.4	0.0	78	30	46	20	23	29	35	32	27	72	1.54	−0.7	8	6,162	nw.	38	nw.	21	13	10	7	4.6	2.2	0.0
Chicago	673	7	131	29.30	30.04	+.04	49.2	+2.3	90	11	57	32	2	41	43	42	36	68	2.30	−0.5	10	7,043	ne.	30	nw.	7	11	8	11	5.0	T.	0.0
Green Bay	617	109	141	29.36	30.02	+.01	44.6	+1.4	78	30	54	24	23	35	34	38	32	66	1.01	−1.6	6	7,223	s.	33	nw.	7	7	11	12	6.0	0.1	0.0
Milwaukee	681	125	221	29.29	30.03	+.04	45.4	+1.6	90	10	53	29	24	37	49	39	34	71	2.91	+0.2	9	8,637	e.	40	nw.	7	12	7	11	5.2	1.6	0.0
Duluth	1,133	5	47	28.81	30.05	+.04	40.7	+3.7	70	9	50	18	1	31	40	34	26	61	1.89	−0.2	6	8,041	ne.	43	nw.	5	17	7	6	3.7	1.5	0.0
North Dakota							48.0	+7.1										62	1.75	0.0									5.1		
Moorhead	940	50	58	29.00	30.03	+.04	46.3	+5.7	75	4	58	21	1	35	39	40	32	62	2.16	0.0	7	5,509	s.	27	nw.	5	13	4	13	5.3	0.6	0.0
Bismarck	1,674	8	57	28.19	29.98	+.01	49.4	+7.3	81	8	61	21	1	38	44	42	33	61	1.37	−0.2	6	6,215	se.	35	n.	20	14	5	11	4.9	1.2	0.0
Devils Lake	1,478	11	44	28.42	30.02	+.03	46.2	+7.4	76	4	57	21	21	35	39	39	33	66	1.05	−0.5	9	6,397	se.	34	nw.	20	12	8	10	5.2	T.	0.0
Ellendale	1,457	10	56	28.45	30.03		47.2		80	4	60	21	1	35	43				2.21	+0.1	7	8,894	se.	44	nw.	5	10	7	13	5.8	1.8	0.0
Grand Forks	833	12	67				45.3		76	4	57	20	22	34	43	40			1.74		8		se.	40	nw.	21	18	7	5		T.	0.0
Williston	1,878	41	48	27.97	29.96	.00	50.0	+8.0	79	8	62	19	1	38	39	41	32	58	1.96	+0.8	12	5,781	se.	33	nw.	4	15	8	7	4.2	0.5	0.0
Upper Mississippi Valley							53.8	+3.6										61	2.10	−0.8									4.8		
Minneapolis	918	102	208	29.00	29.99		49.4	+3.0	81	9	60	22	1	39	39				0.62	−1.6	5	8,046	nw.	43	ne.	17	14	3	13	5.1	0.0	0.0
St. Paul	837	236	261	29.11	30.03	+.04	49.3	+3.7	79	9	60	22	1	39	38				0.75	−1.6	5	8,425	se.	39	nw.	6	14	7	9	4.7	T.	0.0
La Crosse	714	11	48	29.23	30.00	+.02	50.1	+2.9	91	10	61	22	1	40	40	42	34	62	1.73	−0.7	8	3,470	nw.	19	nw.	6	13	5	12	5.0	1.0	0.0
Madison	974	70	78	28.97	30.03	+.04	47.4	+2.0	89	10	57	26	1	38	41	40	33	64	2.95	+0.2	10	6,085	nw.	28	nw.	7	15	4	11	4.8	5.8	0.0
Wausau	1,247	4	64	28.69	30.04		46.2		78	10	58	22	1	35	40				1.55	−1.1	5	4,489	n.	26	n.	6	15	6	9	4.9	T.	0.0
Charles City	1,015	10	51	28.94	30.03	+.05	49.4	+3.0	90	10	61	17	1	38	40	42	35	64	3.47	+1.0	10	4,987	se.	19	sw.	10	15	7	8	4.1	0.5	0.0
Davenport	606	71	79	29.35	30.01	+.03	53.3	+3.4	91	11	64	31	1	43	35	44	36	60	2.96	+0.3	10	7,864	nw.	37	sw.	11	13	8	9	4.7	T.	0.0
Des Moines	861	5	99	29.09	30.00	+.03	53.6	+3.5	92	10	65	28	1	43	38	45	36	60	2.35	−0.6	10	6,805	e.	31	s.	17	8	9	13	5.8	0.2	0.0
Dubuque	700	81	96	29.26	30.02	+.04	50.6	+2.0	92	10	60	26	1	41	36	43	36	64	4.34	+1.5	11	4,645	nw.	27	nw.	6	14	7	9	4.4	2.0	0.0
Keokuk	614	64	78	29.34	30.02	+.04	56.8	+4.5	92	10	68	31	2	46	33	46	37	58	1.97	−1.0	6	5,310	n.	26	sw.	17	11	9	10	5.2	0.0	0.0
Cairo	358	87	93	29.66	30.04	+.05	62.2	+4.1	87	11	71	40	25	53	28	52	43	56	0.79	−2.9	10	5,585	s.	26	sw.	1	10	7	13	5.6	0.0	0.0
Peoria	609	11	45	29.36	30.02	+.03	55.0	+4.1	92	10	67	31	8	43	38	46	39	60	3.58	+0.2	9	4,952	nw.	22	sw.	10	15	7	8	4.0	0.0	0.0
Springfield, Ill	636	154	191	29.33	30.02	+.04	56.7	+4.0	90	11	67	32	2	46	37	50	44	69	1.55	−2.0	6	8,632	s.	34	s.	17	10	12	8	5.0	0.0	0.0
Hannibal	534	74	109	29.45	30.02	+.04	58.4	+5.0	93	10	70	33	25	47	34				1.63	−1.6	7	6,199	sw.	35	sw.	29	12	7	11	4.7	T.	0.0
St. Louis	568	265	303	29.41	30.01	+.03	61.2	+5.4	93	10	70	39	2	52	39	50	41	53	1.32	−2.5	6	7,939	s.	36	sw.	17	12	14	4	4.1	0.0	0.0
Missouri Valley							56.1	+5.0										61	2.89	+0.1									5.3		
Columbia, Mo	784	6	84	29.17	30.01	+.03	59.9	+5.0	93	10	71	33	8	49	34				1.55	−2.2	13	5,510	se.	27	sw.	17	11	10	9	4.9	0.0	0.0
Kansas City	963	161	181	28.96	29.99	+.03	60.4	+5.6	92	10	70	31	1	50	35	50	42	59	3.13	0.0	13	6,900	s.	29	sw.	17	12	10	8	4.6	0.0	0.0
St. Joseph	967	11	49	28.95	29.98		59.0		92	10	70	30	1	48	37	48	39	57	2.92	−0.1	13	6,001	se.	34	w.	11	14	7	9	4.6	0.0	0.0
Springfield, Mo	1,324	98	104	28.62	30.02	+.05	60.4	+4.4	87	10	70	40	21	51	33	50	40	54	1.04	−2.8	12	7,261	s.	35	se.	26	19	7	4	2.8	0.0	0.0
Iola	984	11	50	28.94	29.98	+.03	61.2	+5.0	92	10	74	36	21	49	46				4.14	+0.6	8	4,552	s.	21	w.	17	11	11	8	4.9	0.0	0.0
Topeka	987	92	107				60.1	+5.4	93	9	72	30	1	48	44				4.52	+1.7	13	6,465	e.	31	sw.	10	12	10	8	4.8	0.0	0.0
Lincoln	1,189	11	81	28.71	29.97	+.03	55.6	+4.1	92	10	67	23	1	44	44	47	40	66	2.72	+0.2	12	6,219	e.	31	nw.	5	8	8	14	6.0	0.0	0.0
Omaha	1,105	115	122	28.81	29.99	+.04	55.9	+4.7	93	10	66	28	1	46	34	46	36	56	2.37	−0.1	9	4,954	e.	30	nw.	5	12	5	13	5.5	0.0	0.0
Valentine	2,598	47	54	27.26	29.98	+.04	51.8	+6.1	90	9	64	14	1	39	45	44	37	66	4.69	+2.8	13	5,811	e.	30	n.	4	7	10	13	6.0	6.0	0.0
Sioux City	1,135	94	164	28.79	30.01	+.06	52.8	+5.0	84	10	63	23	1	42	37	44	36	61	2.00	−0.7	12	7,739	se.	39	nw.	5	9	5	16	6.4	0.1	0.0
Huron	1,306	59	74	28.61	30.02	+.06	50.3	+5.2	86	9	61	20	1	39	45	43	37	67	1.74	−0.5	10	6,263	se.	30	w.	5	12	5	13	5.6	1.0	0.0
Pierre	1,572	70	75	28.30	29.97	+.02	52.6	+5.8	87	8	64	26	1	41	46	44	36	61	3.68	+1.9	11	6,009	e.	36	e.	14	9	6	15	6.0	T.	0.0
Yankton	1,233	49	57	28.68	30.00	+.05	52.2	+4.3	79	9	63	23	1	42	42				3.08	+0.3	13	4,953	e.	30	nw.	5	8	5	17	6.6	2.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1930*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. mean min.	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	N	°F.		In.	In.		Miles								0–10	In.	In.
Northern Slope							50.7	+7.5										58	1.28	−0.3										5.6		
Billings	3,140	5		27.28	29.91	−.02	53.2		87	7	71	24	1	36	56				0.87		8		nw.				5	19	6		0.0	0.0
Havre	2,505	11	44	25.74	29.91	−.06	52.0	+8.3	80	7	66	25	1	38	41	42	32	56	1.12	+0.1	6	5,445	sw.	38	sw.	4	11	12	7	5.0	T.	0.0
Helena	4,124	89	113	25.74	29.91	−.06	51.0	+7.5	77	7	63	28	1	39	38	42	34	57	0.78	−0.3	9	5,250	sw.	28	sw.	24	0	14	16	7.4	0.0	0.0
Kalispell	2,973	48	56	26.85	29.90	−.06	49.4	+5.8	72	7	62	28	1	37	37	41	31	56	1.32	+0.5	7	3,905	nw.	28	sw.	13	10	17	3	4.7	0.0	0.0
Miles City	2,371	48	55	27.41	29.96	.00	53.8	+9.1	82	7	66	24	1	41	40	44	35	56	1.88	+0.8	10	4,159	s.	28	se.	13	9	15	6	4.8	0.0	0.0
Rapid City	3,259	50	58	26.57	29.98	+.03	52.6	+8.3	84	8	65	19	1	40	47	44	35	58	1.67	−0.4	10	4,893	n.	31	w.	28	7	13	10	6.0	T.	0.0
Cheyenne	6,088	84	101	23.98	29.92	+.01	49.2	+8.3	76	8	61	10	1	37	41	41	34	63	1.19	−0.8	11	7,042	w.	39	w.	4	6	12	12	6.2	0.4	0.0
Lander	5,372	60	68	24.59	29.91	−.03	50.6	+8.2	76	25	65	11	1	36	43	40	30	52	0.10	−2.0	3	3,691	w.	33	sw.	27	14	14	2	4.2	0.0	0.0
Sheridan	3,790	10	47	26.04	29.92		51.2		82	7	67	18	1	35	48	42	34	60	0.64	−1.3	11	3,388	nw.	24	e.	13	9	18	3	4.7	T.	0.0
Yellowstone Park	6,241	11	48	23.86	29.97	+.01	43.8	+6.8	69	21	56	18	1	32	39	36	28	60	0.62	−0.8	12	4,503	sw.	25	sw.	30	2	14	14	7.0	0.7	0.0
North Platte	2,821	11	51	27.03	29.95	+.03	54.2	+5.6	92	9	67	22	1	41	46	45	36	63	3.46	+1.4	8	4,857	se.	28	n.	17	12	4	14	5.8	0.3	0.0
Middle Slope							59.7	+6.2										54	2.18	−0.3										5.3		
Denver	5,292	106	113	24.69	29.90	.00	55.5	+8.4	81	7	68	26	1	43	34	43	31	49	0.60	−1.5	12	4,614	s.	32	nw.	16	10	12	8	5.2	0.0	0.0
Pueblo	4,685	80	86	25.22	29.86	−.02	56.9	+6.8	85	8	72	24	1	42	48	44	32	49	1.24	−0.1	4	4,151	nw.	30	s.	9	12	12	6	4.6	T.	0.0
Concordia	1,392	50	58	28.52	30.00	+.07	57.4	+3.9	93	9	69	26	1	46	43	47	38	59	3.51	+1.2	10	5,462	e.	29	nw.	17	11	8	11	5.4	0.0	0.0
Dodge City	2,509	11	51	27.37	29.96	+.06	59.4	+5.8	91	9	74	29	1	45	45	48	39	56	2.79	+0.8	9	6,109	se.	26	s.	10	16	7	7	4.1	0.0	0.0
Wichita	1,358	139	158	28.52	29.94	+.01	62.0	+5.6	91	9	73	34	1	51	39	50	40	54	1.68	−1.2	7	8,390	s.	48	sw.	10	10	12	8	5.0	0.0	0.0
Broken Arrow	765	11	56	29.16	29.98		63.4		88	10	74	42	8	52	34				3.14	−0.6	10	9,011	s.	44	s.	29	9	12	9	5.4	0.0	0.0
Oklahoma City	1,214	10	47	28.67	29.94	+.02	66.8	+7.0	90	9	78	46	3	55	35	55	46	57	2.30	−1.0	5	6,739	s.	27	s.	19	12	6	12	5.2	0.0	0.0
Southern Slope							68.2	+5.4										47	1.74	−0.1										4.3		
Abilene	1,738	10	52	28.13	29.91	+.01	72.8	+8.4	96	7	87	48	6	59	41	55	41	44	2.23	−0.5	2	7,211	s.	32	s.	10	9	12	9	5.5	0.0	0.0
Amarillo	3,676	10	49	26.23	29.90	+.03	63.4	+7.6	88	9	77	35	1	50	41	49	36	46	2.19	+0.4	6	6,141	s.	30	nw.	16	17	9	4	3.6	0.0	0.0
Del Rio	944	64	71	28.93	29.90	+.01	73.2	+2.6	94	5	84	51	4	62	39	61	52	58	2.01	+0.2	5	6,448	se.	40	e.	28	10	12	8	4.8	0.0	0.0
Roswell	3,566	75	85	26.32	29.88	+.03	63.6	+3.0	89	7	80	38	17	48	44	48	32	40	0.53	−0.4	3	4,900	s.	29	nw.	10	18	9	3	3.2	0.0	0.0
Southern Plateau							62.3	+5.0										39	0.25	−0.1										3.0		
El Paso	3,778	152	175	26.13	29.85	+.02	68.6	+5.2	90	20	82	48	18	56	36	48	27	26	T.	−0.3	0	6,291	w.	36	nw.	1	21	8	1	2.8	0.0	0.0
Santa Fe	7,013	38	53	23.24	29.88	+.04	52.4	+5.7	75	21	66	25	2	39	35	39	24	41	0.81	−0.2	3	4,049	e.	23	sw.	9	14	12	4	3.8	T.	0.0
Flagstaff	6,907	10	59	23.34	29.89	+.05	47.5	+5.3	74	20	62	23	17	32	45	37		58	1.43		5	5,022	nw.	26	sw.	24	11	13	6		T.	0.0
Phoenix	1,108	10	107	28.71	29.86	−.01	72.2	+5.2	98	20	87	47	2	58	43	53	36	33	0.20	−0.2	1	3,523	e.	21	nw.	13	15	12	3	3.2	0.0	0.0
Yuma	141	9	54	29.71	29.86	−.03	73.1	+3.6	103	6	89	47	14	57	43	56	40	38	0.02	−0.1	1	3,048	w.	22	w.	13	21	7	2	2.4	0.0	0.0
Independence	3,957	6	27	25.90	29.90	.00	60.0	+4.9	86	7	76	35	1	44	42	44			0.22	+0.1	1		nw.				21	5	4		0.0	0.0
Middle Plateau							53.5	+5.1										44	0.79	−0.2										4.8		
Reno	4,532	74	81	25.43	29.93	−.04	51.2	+3.9	80	5	65	29	1	37	44	41	31	53	0.66	+0.2	6	4,927	w.	38	w.	14	12	12	6	4.4	0.8	0.0
Tonopah	6,090	12	20				52.4		75	20	63	28	15	42	28	39	24	38	0.74		5		se.									
Winnemucca	4,344	18	56	25.57	29.94	−.02	51.4	+4.7	80	20	68	23	1	35	49	39	27	45	0.34	−0.5	6	4,378	sw.	26	w.	14	12	13	5	4.6	T.	0.0
Modena	5,473	10	43	24.57	29.88	.00	50.0	+4.0	78	21	67	21	16	34	46	38	25	44	0.65	−0.2	4	7,445	sw.	36	s.	24	10	12	8	5.1	T.	0.0
Salt Lake City	4,360	163	203	25.58	29.91	−.01	56.8	+7.2	81	21	68	36	15	46	33	44	32	45	1.48	−0.6	12	4,828	s.	33	w.	8	8	15	7	5.0	T.	0.0
Grand Junction	4,602	60	68	25.34	29.89	+.01	58.2	+5.8	83	21	71	35	1	45	35	44	29	41	0.84	0.0	7	4,014	se.	28	sw.	13	11	14	5	4.7	0.0	0.0
Northern Plateau							54.6	+5.2										53	1.28	+0.1										5.8		
Baker	3,471	48	53	26.40	29.98	−.02	49.4	+4.2	77	6	63	26	1	36	39	41	33	50	1.71	+0.6	12	3,855	se.	30	sw.	3	5	12	13	6.6	0.0	0.0
Boise	2,739	78	86	27.11	29.96	−.02	55.6	+5.2	83	6	68	33	14	43	36	45	35	51	2.04	+0.9	9	2,874	se.	19	sw.	26	7	12	11	6.0	T.	0.0
Lewiston	757	40	48	29.16	29.97	−.02	57.2	+4.4	82	12	70	35	1	45	37				1.48	+0.4	11	1,738	e.	20	nw.	3	8	11	11	6.1	0.0	0.0
Pocatello	4,477	60	68	25.43	29.93	−.01	53.1	+7.1	80	21	65	30	1	41	39	42	31	50	0.90	−0.5	13	5,210	se.	30	sw.	26	5	20	5	5.1	0.0	0.0
Spokane	1,929	101	110	27.91	29.95	−.04	53.8	+5.4	80	12	66	32	10	42	42	44	35	56	0.88	−0.2	9	3,957	s.	21	sw.	3	10	9	11	5.7	0.0	0.0
Walla Walla	991	57	65	28.88	29.95	−.06	58.2	+5.1	80	20	69	40	30	48	32	48	37	51	0.68	−0.8	11	2,940	s.	21	se.	12	9	10	11	5.5	0.0	0.0
North Pacific Coast Region							53.2	+3.6										73	2.34	−0.3										7.1		
North Head	211	11	56	29.79	30.02	−.03	50.8	+3.3	69	11	55	40	10	46	23	48	46	86	2.57	−1.6	20	9,795	s.	62	s.	3	4	12	14	7.0	0.0	0.0
Port Angeles	29	8	53		30.01		48.7		62	19	56	35	16	42	20				0.81	−0.7	11	3,649	sw.	28	w.	27	3	7	20		0.0	0.0
Seattle	125	215	250	29.86	29.99	−.04	52.8	+3.4	69	22	60	38	2	46	25	48	43	74	1.82	−0.6	15	5,140	s.	35	sw.	26	3	11	16	6.9	0.0	0.0
Tacoma	194	172	201	29.79	30.00	−.03	52.7	+4.0	70	22	61	37	2	45	28				2.16	−0.6	14	5,219	n.	31	s.	3	3	15	12	6.8	0.0	0.0
Tatoosh Island	86	9	53	29.88	29.98	−.02	48.8	+2.7	58	20	52	40	10	45	12	47	46	92	7.13	+1.5	20	8,591	s.	58	s.	4	2	5	23	8.5	0.0	0.0
Yakima	1,076	58	67	28.80	29.95		56.0	+3.5	80	21	69	33	1	43	41	45	33	48	0.08	−0.4	5	3,591	nw.	29	sw.	3	8	11	11	5.6	0.0	0.0
Medford	1,329	29	58	28.56	29.97		54.4		78	19	67	32	9	41	44	47	40	66	1.09	−0.2	10		nw.	32	se.	13	5	7	18	7.4	0.0	0.0
Portland, Oreg	153	68	106	29.84	30.00	−.06	55.8	+4.0	77	11	64	38	2	47	32	50	45	72	2.72	−0.2	18	3,308	nw.	20	s.	3	7	2	21	7.7	0.0	0.0
Roseburg	510	75	99	29.45	30.00	−.07	55.2	+4.2	78	11	66	36	1	45	39	49	43	70	2.67	+0.4	12	2,465	nw.	25	sw.	3	6	6	18	6.8	0.0	0.0
Middle Pacific Coast Region							58.5	+2.8										72	1.28	−0.6										4.7		
Eureka	62	73	89	29.99	30.06	−.05	53.6	+3.7	66	20	59	42	5	48	23	50	46	78	2.54	−0.8	9	4,610	sw.	26	n.	29	6	8	16	6.4	0.0	0.0
Red Bluff	330	5	58	29.62	29.97	−.06	61.4	+2.4	84	30	74	42	4	49	36	52	45	60	0.58	−1.1	5	4,034	s.	26	se.	14	9	14	7	5.2	0.0	0.0
Sacramento	69	106	117	29.92	29.99	−.02	59.3	+1.2	79	20	71	41	9	48	32	54	49	73	0.94	−0.6	6	4,605	s.	23	sw.	13	20	8	2	2.6	0.0	0.0
San Francisco	155	208	243	29.86	30.02	−.03	59.2	+4.2	76	5	66	47	13	52	24	53	49	75	1.56	0.0	8	5,086	w.	27	w.	8	10	17	3	4.4	0.0	0.0
San Jose	141	12	110	29.88	30.03		59.0	+2.3	81	6	71	38	9	47	35				0.76	−0.3	3	3,953	nw.	23	nw.	29	8	15	7	4.9	0.0	0.0
South Pacific Coast Region							62.9	+3.6										68	0.55	−0.4										4.2		
Fresno	327	89	98	29.63	29.99	.00	63.2	+3.0	84	21	76	43	9	51	36	53	44	55	0.45	−0.5	6	5,417	nw.	22	nw.	26	16	13	1	3.1	0.0	0.0
Los Angeles	338	159	191	29.62	29.98	−.01	63.6	+4.2	87	5	72	50	2	55	27	55	50	69	0.15	−0.9	2	3,259	sw.	17	ne.	30	12	15	3	3.9	0.0	0.0
San Diego	87	62	70	29.88	29.97	−.02	62.0	+3.5	79	6	68	51	2	56	21	57	54	79	1.06	+0.3	5	4,242	w.	28	s.	30	7	16	7	5.6	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.91	30.00		77.1	+0.5	90	30	83	68	14	72	17				1.62	−2.7	15	8,920	e.	32	e.	6	5	21	4	5.3	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97	[1] 29.74	[2] 29.83	.00	81.4	−0.2	93	1	89	71	15	74	19			[2] 79	6.78	+3.9	11	6,128	nw.	25	n.	9	1	13	16	7.2	0.0	0.0
Cristobal	36	6	97	[1] 29.82	[2] 29.85	−.01	81.2	−0.6	89	30	85	74	12	77	11	76	74	[2] 80	6.85	+2.6	25	7,737	n.	25	nw.	8	0	12	18	7.6	0.0	0.0
Alaska																																
Fairbanks	455	11	44	[1] 29.34	[1] 29.87		25.4		56	28	37	−18	7	14	40	24	18	65	0.15		5		e.				9	7	14	6.2	1.2	0.0
Juneau	80	11	50	[1] 29.78	[1] 29.87		39.8		60	26	46	27	7	33	29	36	31	74	4.05		20	4,488	e.	35	e.	5	6	5	19	7.0	13.8	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[1] 30.02	[1] 30.06		72.2	−0.8	80	14	76	64	11	68	13	64	59	66	1.36	−0.8	9	7,861	e.	27	e.	12	12	15	3	4.4	0.0	0.0

[1] Pressure not reduced to mean of 24 hours.

[2] Observations taken bihourly.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, April, 1930*

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				33.7		40.9	26.5	47	14	4.67		10.0
Sydney, C. B. I.	48	29.85	29.90	+0.01	37.7	+2.7	46.1	29.3	64	18	2.16	−1.69	3.0
Halifax, N. S.	88	29.83	29.94	−.02	39.5	+1.7	48.9	30.2	66	17	2.97	−1.21	0.2
Yarmouth, N. S.	65	29.84	29.91	−.05	39.3	+0.4	46.0	32.6	56	18	2.47	−1.35	0.0
Charlottetown, P. E. I.	38	29.80	29.84	−.06	37.1	+1.9	44.0	30.3	61	17	1.72	−0.93	6.5
Chatham, N. B.	28	29.78	29.81	−.09	36.6	+1.1	46.1	27.0	62	14	2.44	−0.19	5.8
Father Point, Que.	20												
Quebec, Que.	296	29.62	29.95	−.04	35.7	+0.6	43.2	28.2	63	13	2.69	+0.60	13.6
Doucet, Que.	1,236												
Montreal, Que.	187	29.74	29.95	−.05	40.4	+0.7	49.0	31.7	66	21	2.06	−0.18	3.3
Ottawa, Ont.	236	29.72	29.99	−.03	41.2	+1.2	52.3	30.1	74	19	1.64	+0.14	0.1
Kingston, Ont.	285	29.68	30.00	−.02	38.8	−1.2	44.3	33.4	66	20	2.09	+0.30	0.2
Toronto, Ont.	379	29.60	30.02	.00	42.9	+2.1	51.0	34.7	71	25	1.23	−1.14	0.4
Cochrane, Ont.	930				31.4		41.3	21.6	68	2	1.55		9.5
White River, Ont.	1,244	28.68	30.02	−.02	32.3	−0.7	44.5	20.1	66	−4	1.05	−0.20	0.7
London, Ont.	808				43.9		54.6	33.3	81	24	1.73		3.0
Southampton, Ont.	656	29.30	30.03	.00	39.2	+0.5	48.0	30.4	70	20	2.02	+0.22	4.9
Parry Sound, Ont.	688	29.31	30.01	−.01	36.7	−0.9	44.1	29.2	70	16	2.09	+0.18	7.7
Port Arthur, Ont.	644	29.33	30.04	+.01	37.3	+3.8	45.8	28.7	70	17	1.22	−0.50	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690												
Le Pas, Man.	860				37.7		49.3	26.2	67	11	0.41		0.3
Qu'Appelle, Sask.	2,115	27.70	29.96	−.03	43.4	+6.0	54.5	32.3	73	16	0.83	−0.22	2.5
Moose Jaw, Sask.	1,759				46.9		60.4	33.5	76	19	0.96		0.0
Swift Current, Sask.	2,392												
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.40	29.99	+.01	40.7	+4.6	52.3	29.1	63	14	0.65	−0.18	3.3
Battleford, Sask.	1,592	28.19	29.94	−.03	44.4	+7.2	57.7	31.1	70	13	0.45	−0.02	0.2
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.72	29.97	−.04	50.5	+3.7	56.9	44.1	66	38	1.00	−1.37	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151												
LATE REPORTS, MARCH, 1930													
Winnipeg, Man.	760	29.13	29.99	−.10	19.1	+6.8	28.5	9.8	40	−13	0.98	−0.05	9.8
Calgary, Alb.	3,428	26.36	30.03	+.08	28.8	+2.6	40.8	16.8	69	−20	0.84	+0.12	8.4
Kamloops, B. C.	1,262	28.73	30.05	+.13	39.1	+3.0	49.3	28.9	72	14	0.37	−0.20	0.2
Estevan Point, B. C.	20				42.5		49.2	35.8	64	26	6.34		
Prince Rupert, B. C.	170				38.0		43.3	32.8	56	23	7.89		8.9

Chart I. Departure (°F.) of the Mean Temperature from the Normal, April, 1930

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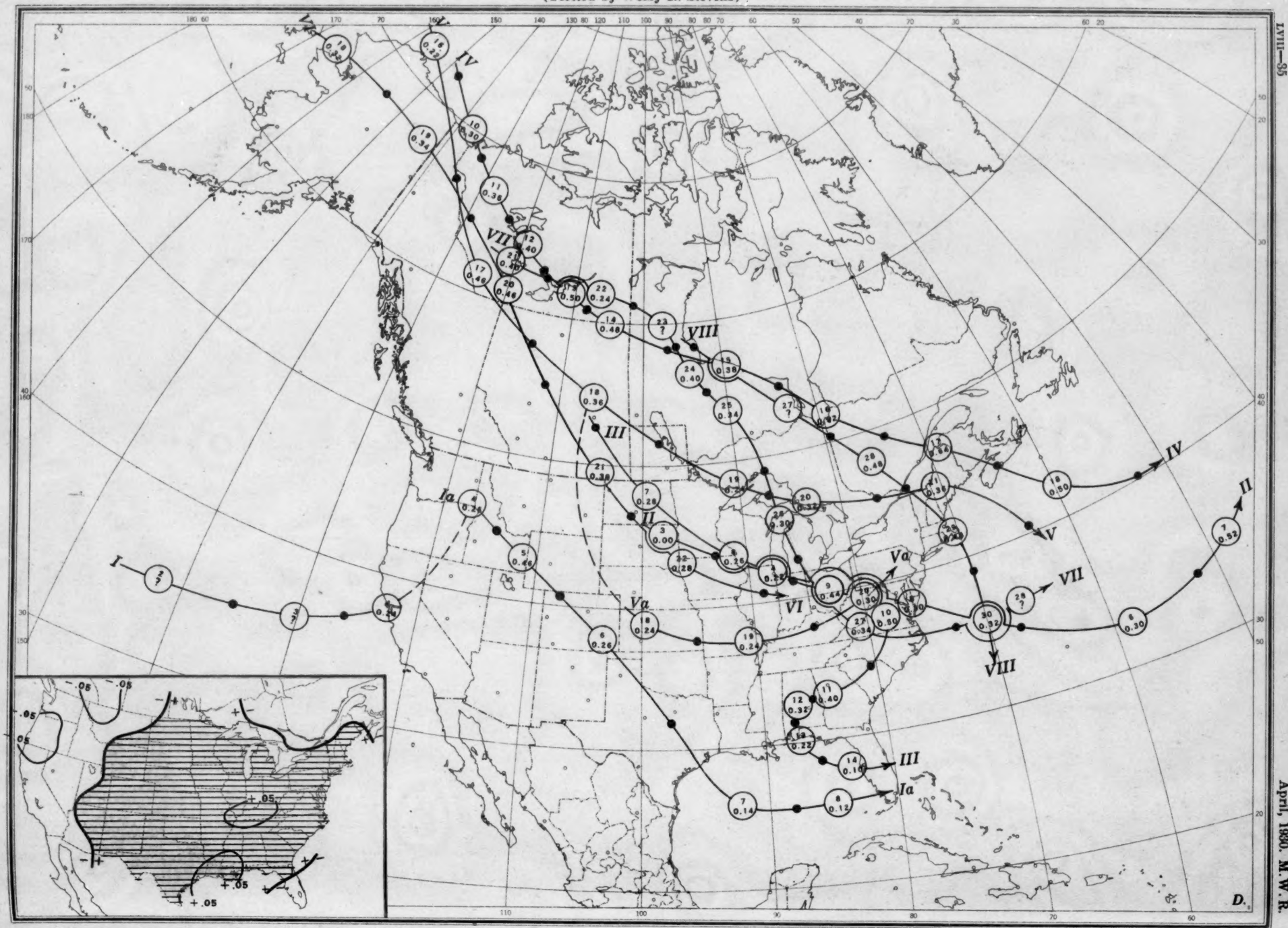
Chart II. Tracks of Centers of Anticyclones, April, 1930. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by Welby R. Stevens)



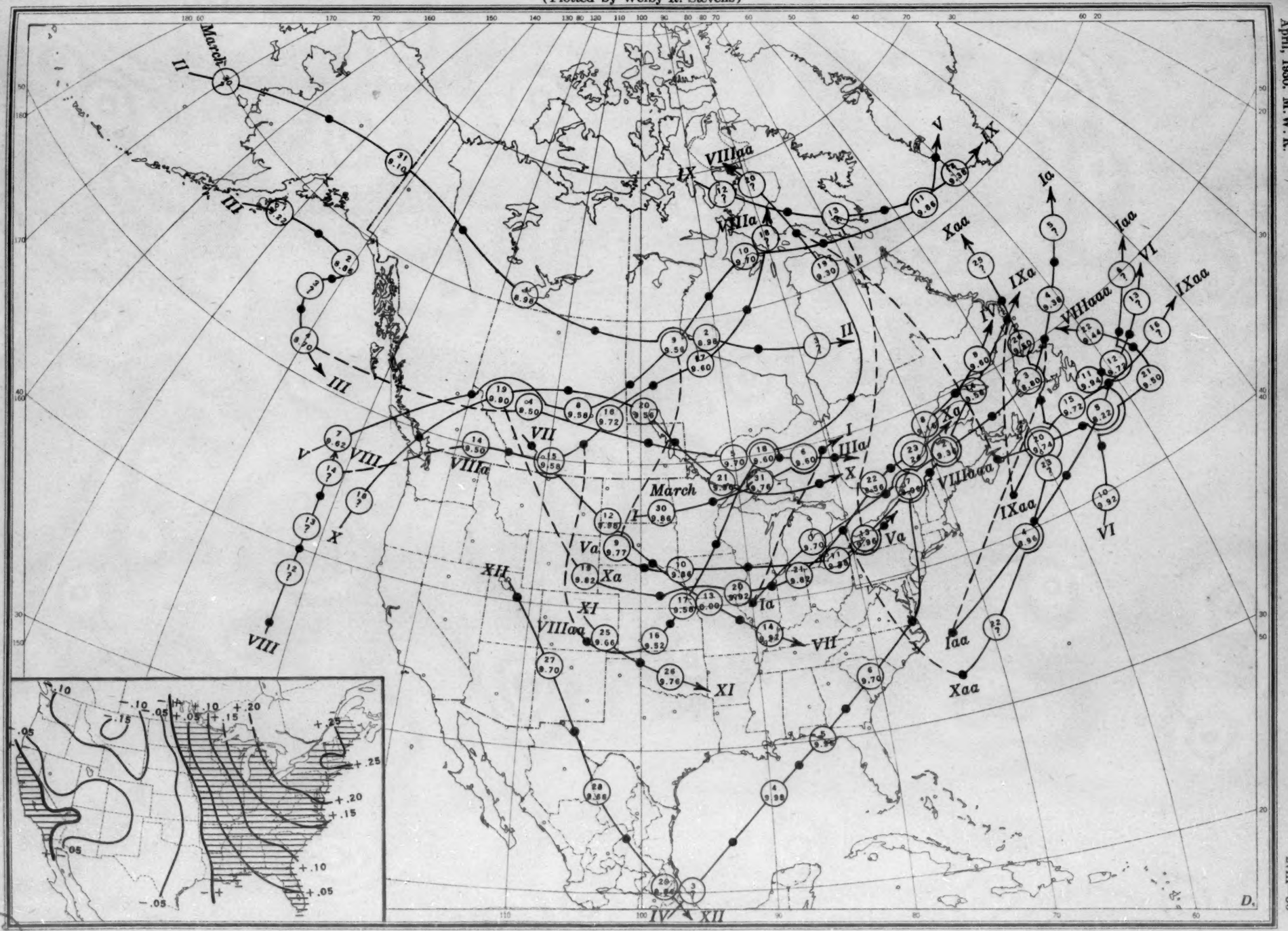
Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, April, 1930. (Inset) Change in Mean Pressure from Preceding Month

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, April, 1930. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by Welby R. Stevens)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, April, 1930

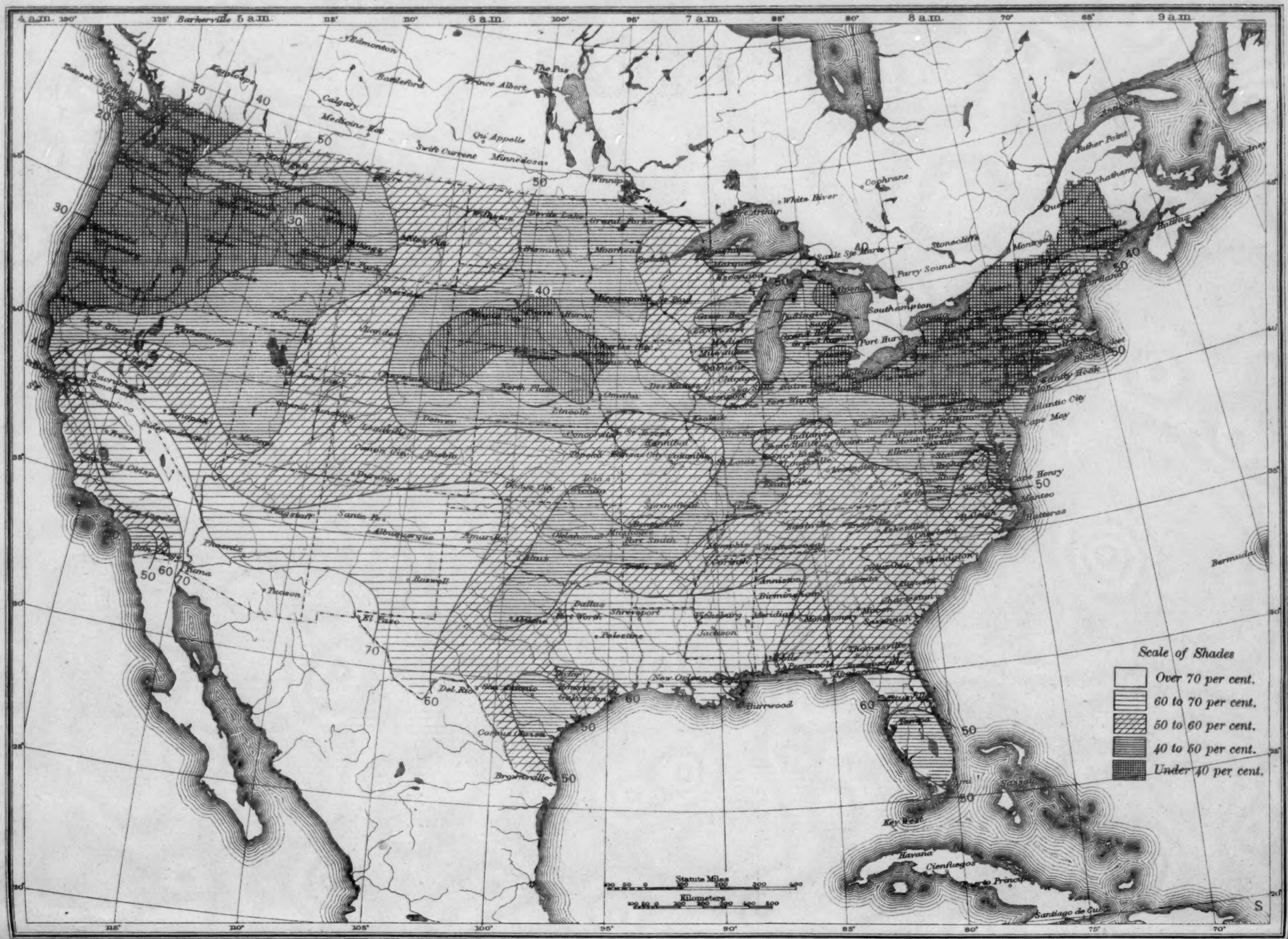


Chart V. Total Precipitation, Inches, April, 1930. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, April, 1930. (Inset) Departure of Precipitation from Normal

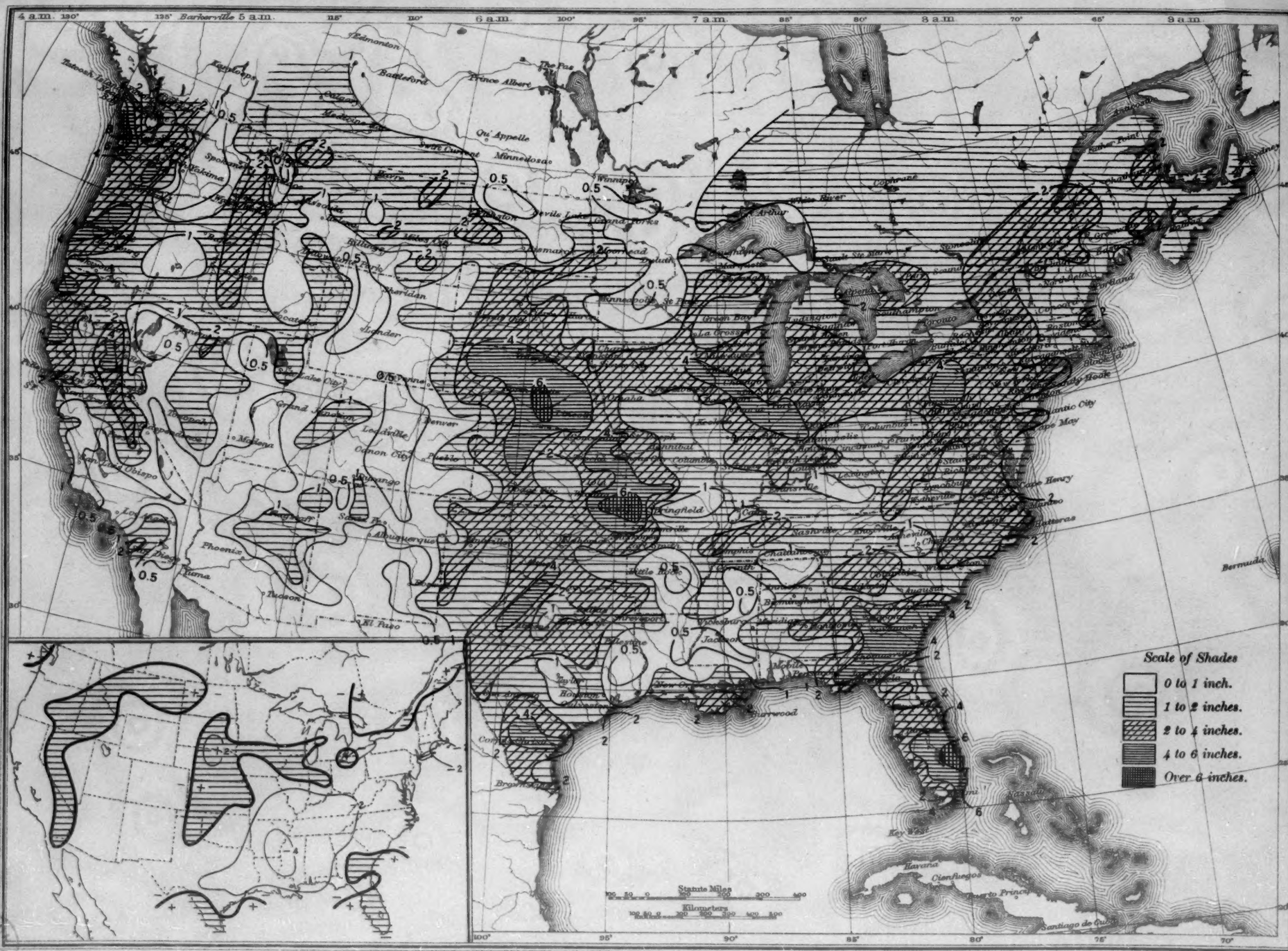


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, April, 1930

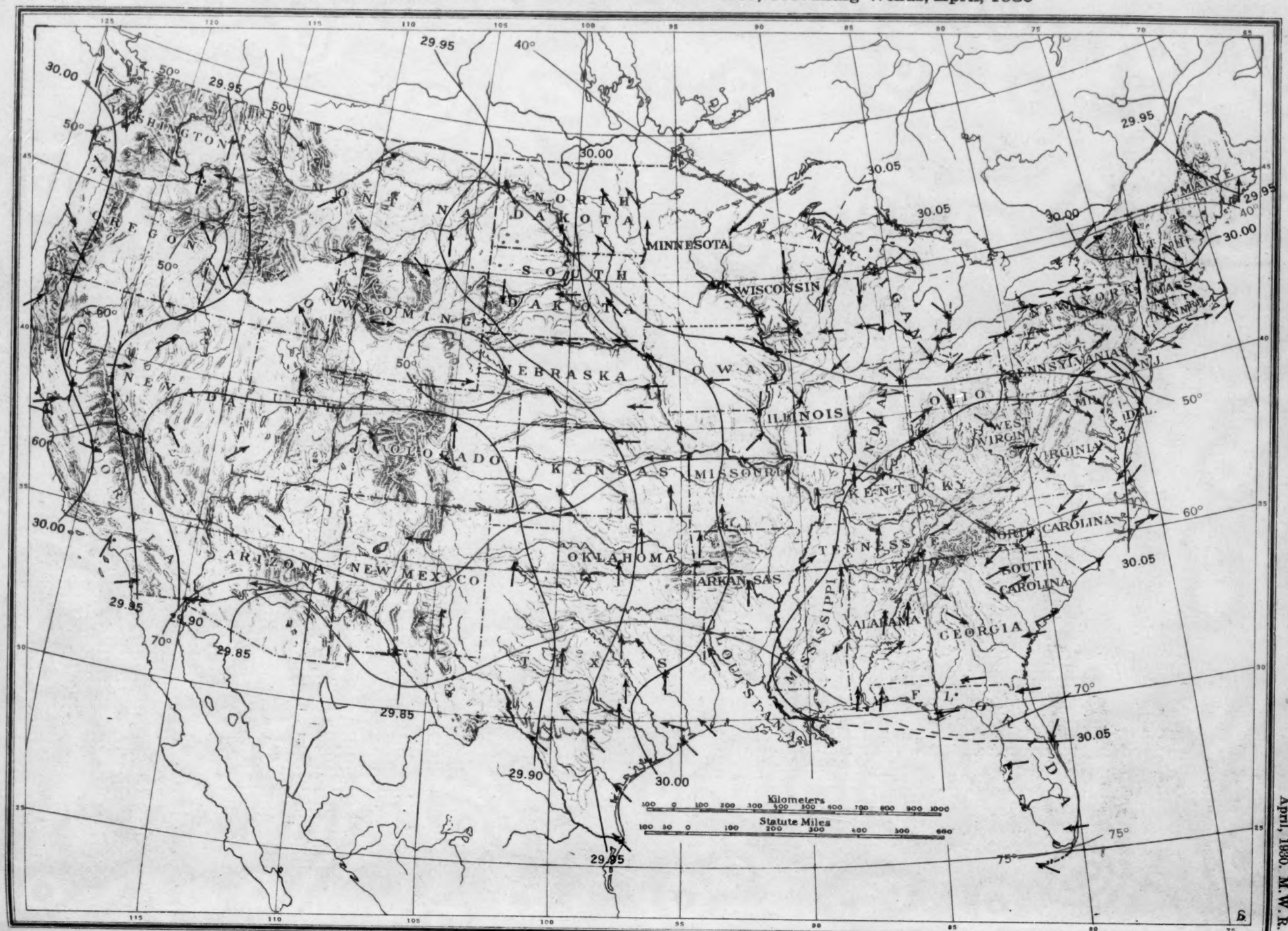


Chart VII. Total Snowfall, Inches, April, 1930.

Chart VIII.—Weather Map of North Atlantic Ocean, April 1, 1920.

Chart VIII. Weather Map of North Atlantic Ocean, April 4, 1930
(Plotted by F. A. Young)

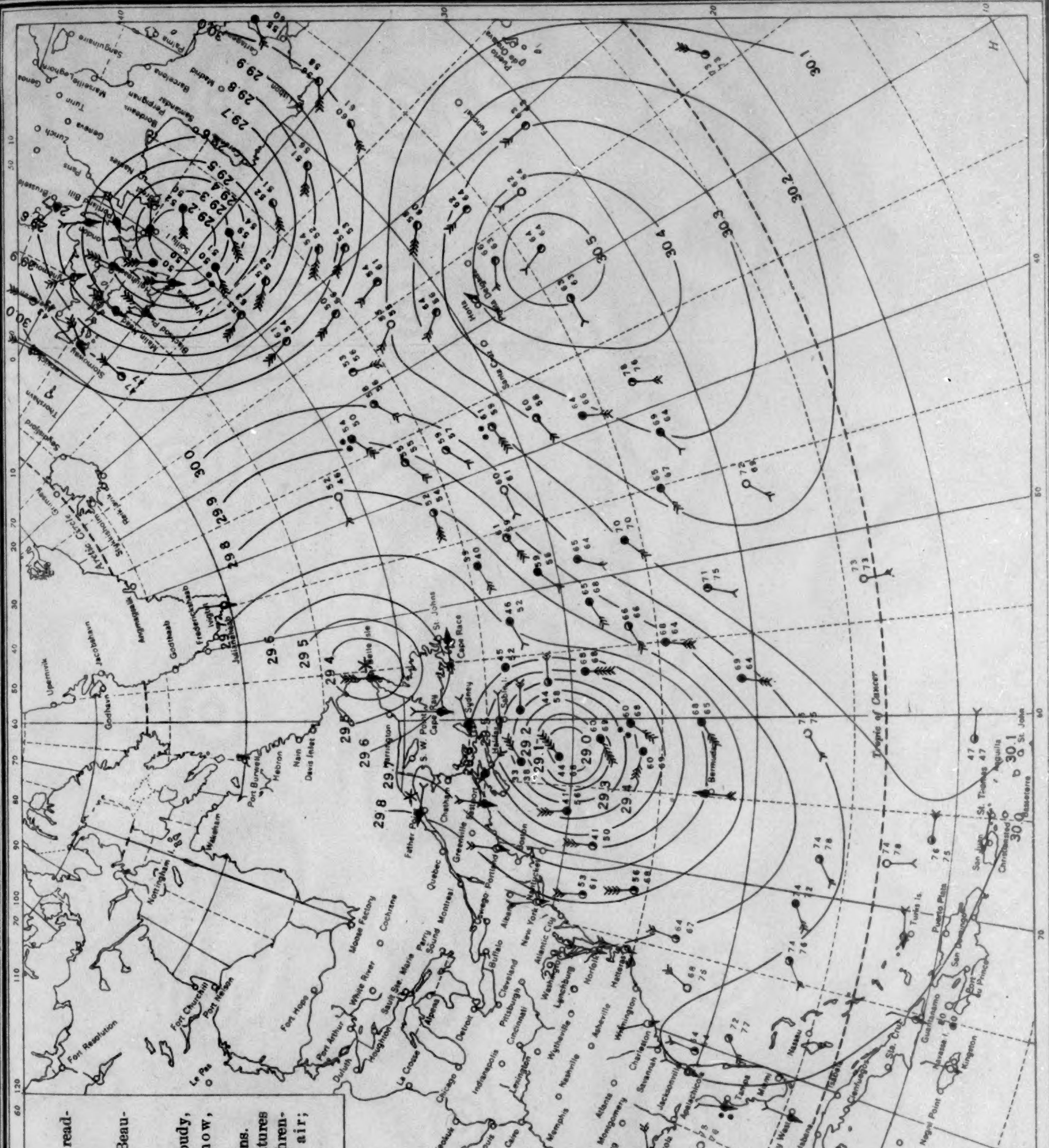


Chart IX. Weather Map of North Atlantic Ocean, April 5, 1930

(Plotted by F. A. Young)

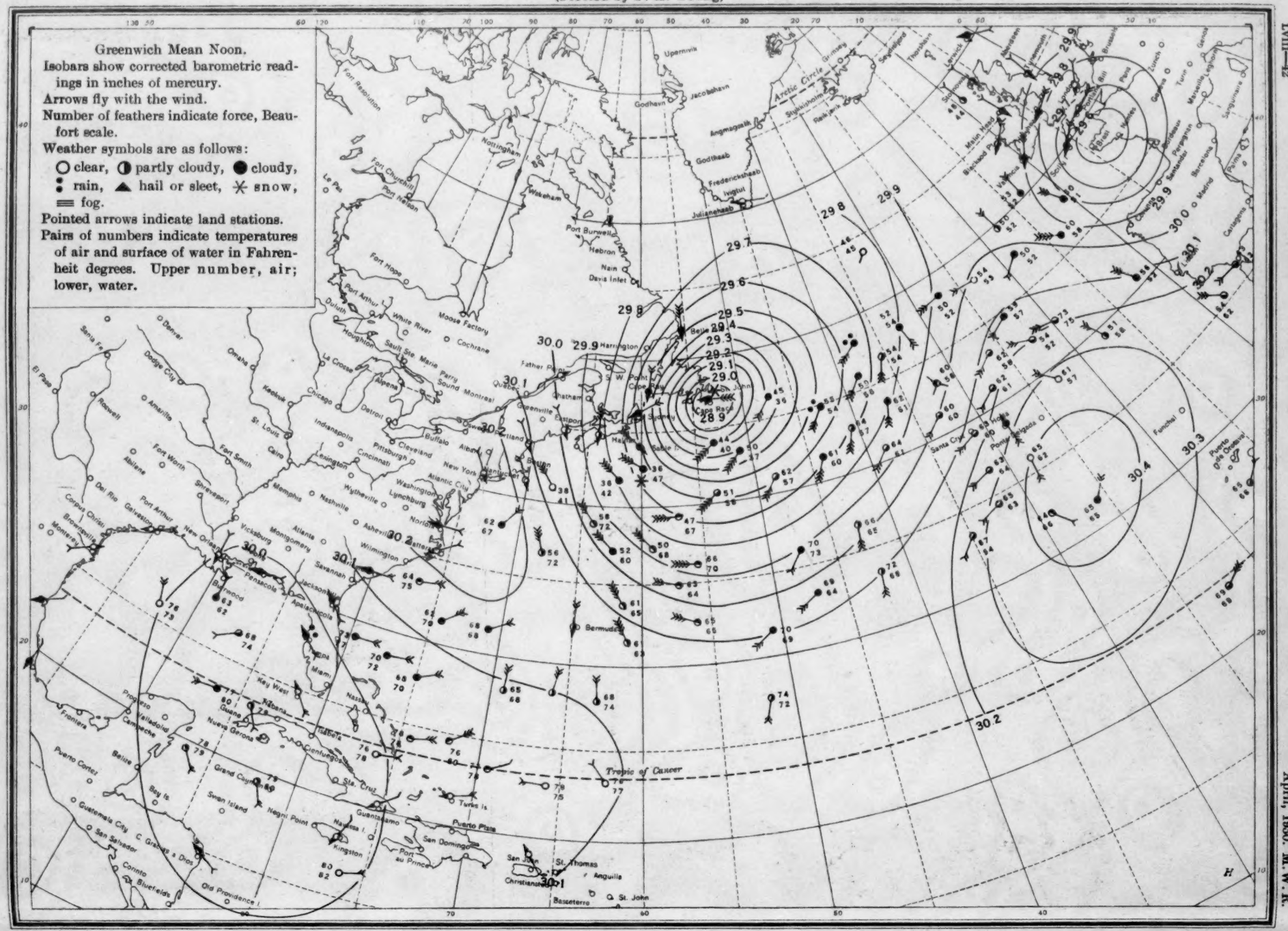


Chart X. Weather Map of North Atlantic Ocean, April 6, 1930

Chart X. Weather Map of North Atlantic Ocean, April 6, 1930

(Plotted by F. A. Young)

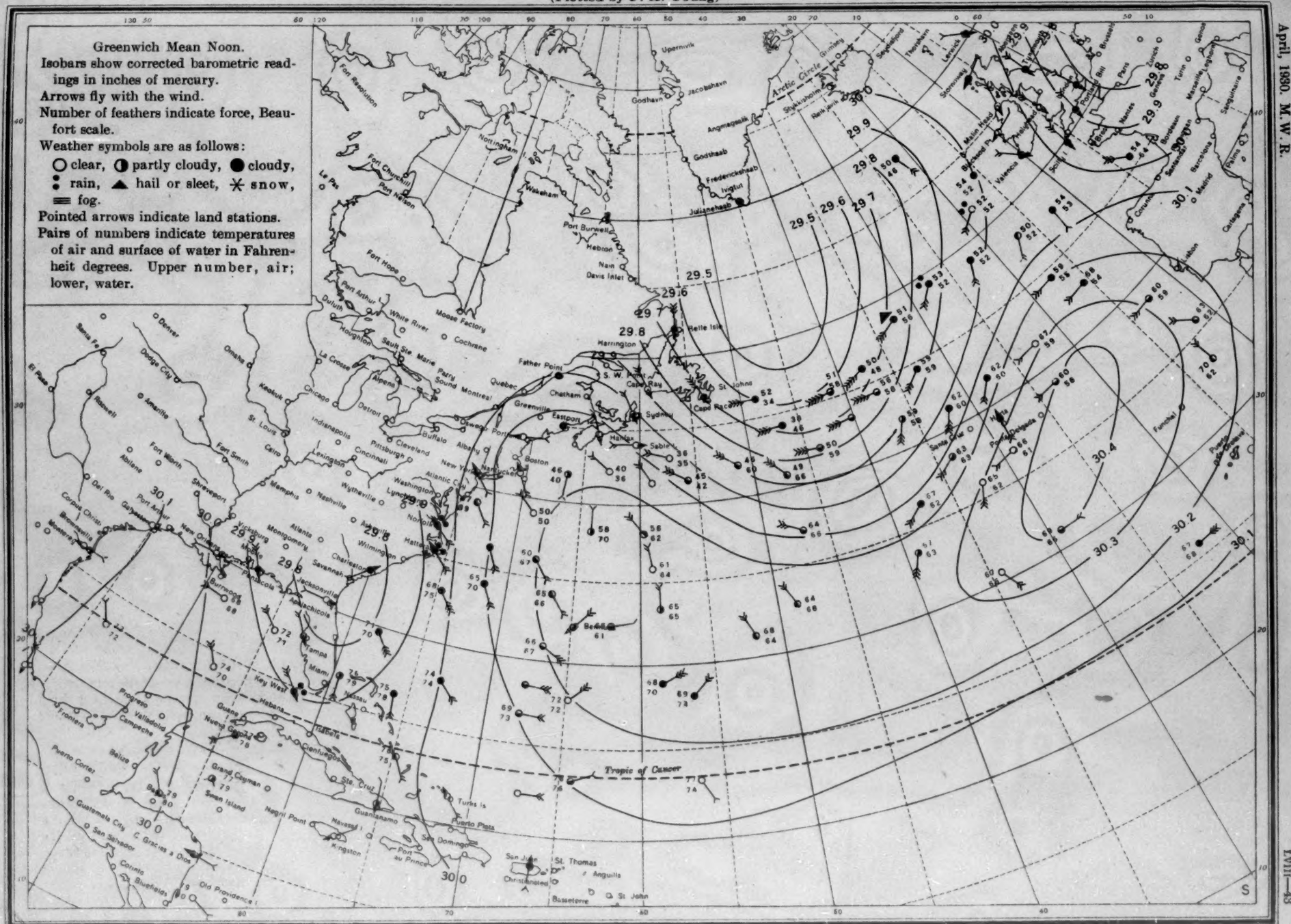
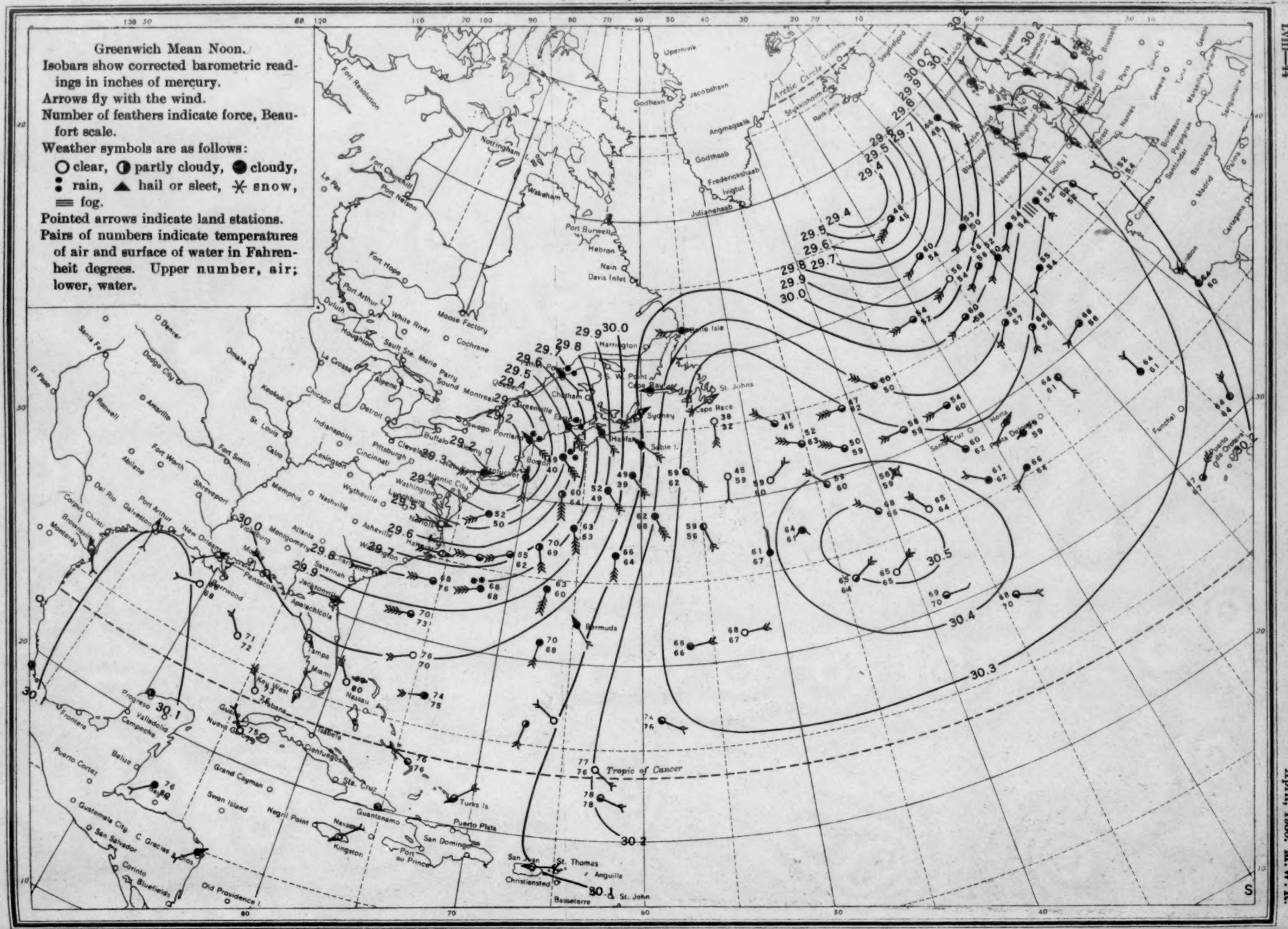


Chart XI. Weather Map of North Atlantic Ocean, April 7, 1930

(Plotted by F. A. Young)